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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 151—No. 3915. LONDON: FRIDAY, JANUARY 24, 1941. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 8d.

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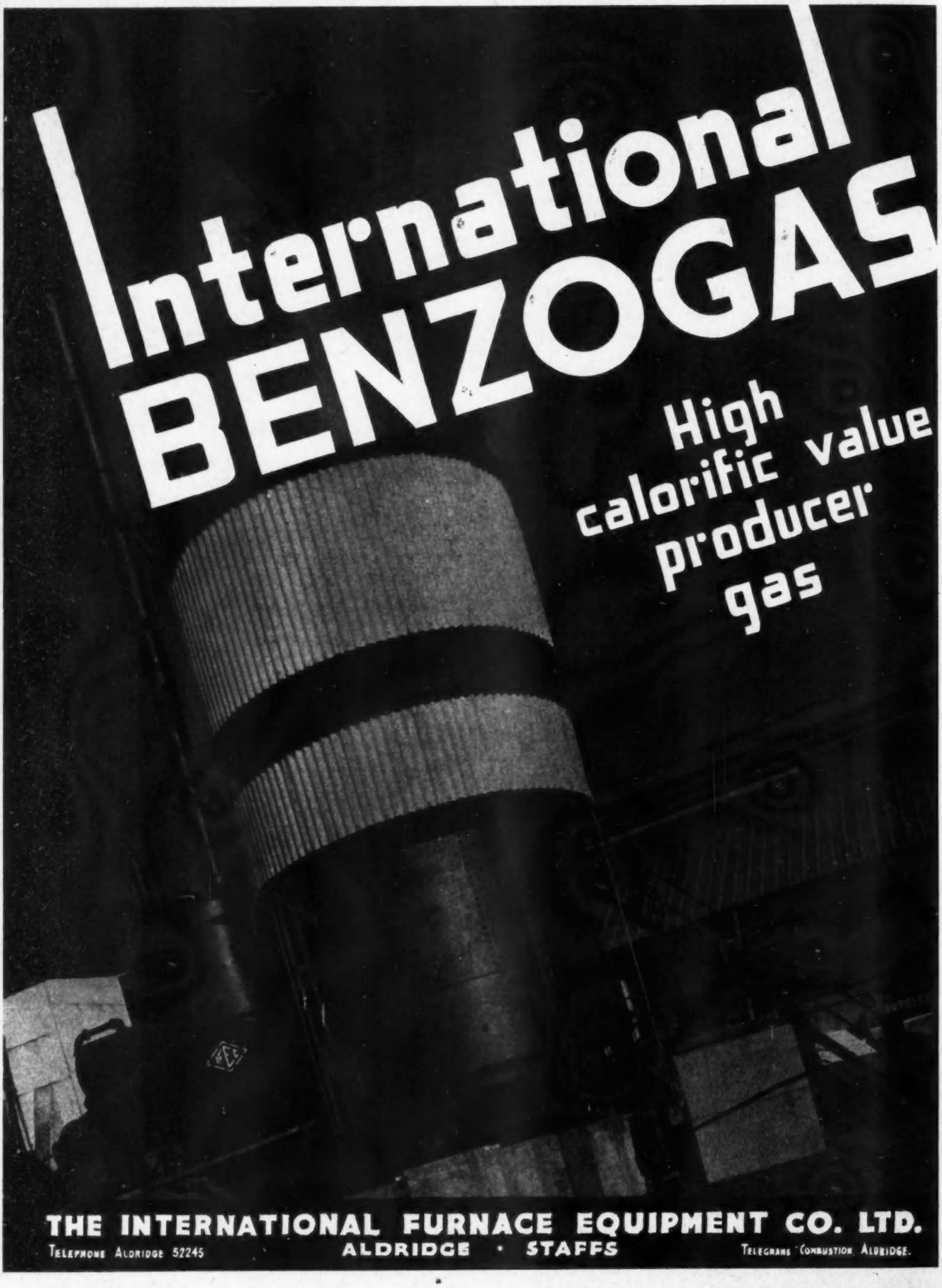
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LOSS OF POWER IN PETROL ENGINES RUNNING ON PRODUCER GAS.

By HAROLD HEYWOOD, Ph.D., M.Sc., M.I.Mech.E.

THE use of producer gas as a fuel for motor-driven vehicles has made considerable progress during the last few years, and the exigencies of war conditions have focused attention upon solid carbonaceous fuel as a partial substitute for petrol or other liquid fuels. The two aspects of the problem are the design of a complete unit, comprising producer, gas cleaners, engine and chassis, specifically for the use of producer gas, and the conversion of existing petrol-driven vehicles to the use of solid fuel. While there is no fundamental difficulty in the design of a producer-gas driven vehicle which would have a performance equal to that of a petrol-driven vehicle, the manufacturing problems involved make it unlikely that such a development will be possible during war-time, although it is only by such means that producer gas will be an economic competitor with petrol under normal conditions. The more urgent problem, in view of a possible shortage of liquid fuel, is the conversion of existing petrol-driven vehicles to the use of producer gas as a fuel, and in this connection a certain degree of inconvenience, due to power loss, reduced load capacity and extra maintenance cost, is inevitable. This article shows theoretically the power losses that occur when a petrol engine is converted to use producer gas as a fuel, and also the influence of various factors on the maximum power that can be developed by a given engine. The theoretical examination of the problem was made as a preliminary to bench-tests of engines carried out at the Experimental Station of the British Coal Utilisation Research Association in the summer of 1940, and the results of these, together with the published results of tests by other investigators, have shown that the theoretical deductions are very closely fulfilled in practice.

The calculations of efficiency and power are prefaced by a few brief notes on the theoretical cycles used for the comparison of engine characteristics. The four-stroke cycle internal-combustion engine is assumed to work on the constant-volume cycle, in which the gaseous charge of fuel and air is compressed adiabatically to a pressure depending upon the clearance volume, exploded while at constant volume, the products of combustion are expanded adiabatically to the same volume as was occupied initially by the charge, and finally the residual heat is rejected at constant volume until the temperature and pressure of the charge are the same as at the beginning of the cycle. The work done during the cycle is represented by the area enclosed within the pressure-volume diagram, and the ideal efficiency is the ratio of the work done to the heat supplied. If air is used as the working fluid for the above cycle of operations, and the specific heat of the air is assumed to remain constant, the efficiency of the cycle is termed the Air Standard Efficiency, and may be calculated from the following equation :—

Air Standard Efficiency $= 1 - \left(\frac{1}{r}\right)^{\gamma-1}$ where r is the compression ratio and γ is the ratio of the specific heat of the working fluid at constant pressure to that at constant volume. The variation in Air Standard Efficiency for $\gamma = 1{\cdot}4$ with different compression ratios is shown in Table I, and the relative indicated powers given in the same table show that the rate of improvement falls off with the higher compression ratios.

The Air Standard Efficiency is only independent of the amount of heat released during the cycle if the specific heat of the working fluid remains constant. If the specific heat increases with rising temperature of the working fluid, then the ideal efficiency is reduced as the heat release per cycle is increased. The constant-volume cycle also assumes that all the heat in the charge is released while the piston remains at the innermost position, but in practice a finite time is required for the process of heat release. Hence, the maximum temperatures and pressures calculated from the constant-volume cycle are considerably greater than those attained in an engine, and a closer approximation to actual conditions is obtained by assuming that part of the heat is released at constant volume and part at constant pressure. This cycle is known as the composite cycle, and the ideal efficiency on this basis is not independent of the heat release, even when the working fluid is assumed to have a constant specific heat at all temperatures.

The pressure-volume diagrams for several of these cycles are plotted in Fig. 1 for a heat release of 38·5 B.Th.U. per cubic foot of swept cylinder volume, for a compression ratio of 6·25. Curve *a* is for the Air Standard Cycle with constant specific heat, curve *b* for the constant-volume air cycle with varying specific heat, and curve *c* for the composite air cycle with half the heat release at constant volume and with varying specific heat. The maximum pressure attained in the composite cycle is approximately equal to that which would be obtained in an actual engine with the above rate of heat release. The ideal efficiencies for constant volume and composite cycles, with a compression ratio of 6·25 to 1 and air as the working fluid, have been calculated for two different heat releases per cycle, both for constant specific heat and for specific heat increasing with temperature. These figures are given in Table II, and show that (*a*) the constant-volume cycle has the higher efficiency and that the greater the proportion of heat released at constant pressure the lower the efficiency; (*b*) an increase in the heat release lowers the ideal efficiency, except for the case of the constant-volume cycle, assuming a working fluid of constant specific heat; and (*c*) efficiencies are lower with a fluid of varying specific heat than with a fluid of constant specific heat.

A study of measured values of maximum pressures obtained with producer gas in engine tests

Fig. 1.

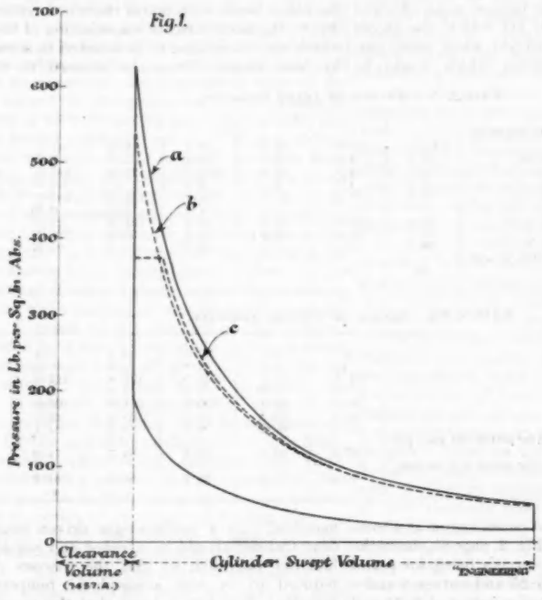


Fig. 2.

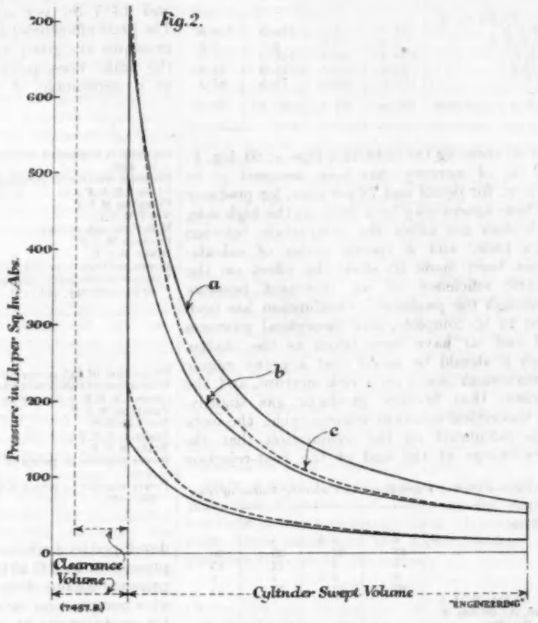


TABLE I.—*Effect of Compression Ratio on Air Standard Efficiency.*

Compression Ratio.	Air Standard Efficiency. Per cent.	Relative Indicated Powers. Per cent. of Power at Compression Ratio of :—		
		5.	6.	8.
5	47·5	100	—	—
6	51·2	108	100	—
7	54·1	114	106	—
8	56·5	119	110	100
9	58·5	123	114	104
10	60·2	127	118	107
11	61·7	130	121	109
12	63·0	133	123	111
13	64·2	135	125	113
14	65·2	137	127	115
15	66·1	139	129	117
16	67·0	141	131	119

TABLE II.—*Ideal Efficiencies, Using Air as Working Fluid at Compression Ratio of 6·25 to 1 ; $\gamma = 1{\cdot}4$.*

Cycle.	Proportion of Heat Release at Constant Volume.	Heat Release per Cub. Ft. of Cyl. Swept Vol., B.Th.U.			
		38·5	77	38·5	77
		Constant Specific Heat.		Varying Specific Heat.	
Constant Volume	The whole.	52·0	52·0	44·4	42·8
Composite	Two-thirds	51·2	51·1	44·3	42·4
Composite	Half ..	50·1	49·6	43·8	41·8
Composite	Quarter ..	46·9	44·9	41·5	38·7
Constant Pressure	None ..	39·5	30·5	35·8	27·6

indicates that about half the heat is released at constant volume and half at constant pressure. The corresponding reduction in the ideal efficiency is, however, so small that it was not considered to warrant the additional work involved in calculating efficiencies by the composite cycle, and consequently the constant-volume cycle of operation has been used throughout the calculations. Allowance has been made for the varying specific heat of the gases according to the values given in *Technical Data on Fuel*, and an index of 1·3 assumed for the compression and expansion curves. The effect of residual exhaust gases left in the cylinder at the completion of the exhaust stroke has also been taken into account.

The volumetric efficiency of the engine, based on gas and air entering the induction pipe at 60 deg. F. and 30 in. of mercury, has been assumed to be 80 per cent. for petrol and 78 per cent. for producer gas. These figures may be a little on the high side, but this does not affect the comparison between the two fuels, and a special series of calculations has been made to show the effect on the volumetric efficiency of an increased pressure drop through the producer. Combustion has been assumed to be complete, and theoretical mixtures of fuel and air have been taken as the charge, although it should be noted that a petrol engine gives maximum power on a rich mixture, and the comparison thus favours producer gas slightly. In the theoretical constant-volume cycle, the work done is calculated on the assumption that the cylinder charge at the end of the heat-rejection period has returned to the same state as at the beginning of the compression stroke. In practice, there is a negative pumping effect, which is due to the excess pressure of the exhaust gases above atmosphere during the exhaust stroke, and to the negative pressure of the fresh charge during the suction stroke. A mean exhaust pressure above atmosphere of 1·8 lb. per square inch has been assumed, and to this must be added the mean negative pressure during the suction stroke. The sum of the two pressures gives the pumping mean effective pressure, and this is subtracted from the gross indicated mean effective pressure (which is calculated from the work done during the theoretical cycle), in order to attain the net indicated mean effective pressure. A friction mean effective pressure of 25·5 lb. per square inch has been taken as applying to an engine of the type which would be used in connection with producer gas, and this figure is subtracted from the net indicated mean effective pressure to obtain the brake mean effective pressure.

TABLE III.—*Ideal Efficiencies and Mean Effective Pressures for Petrol and Producer Gas.*

Fuel	Petrol.	Producer Gas.		
Compression Ratio	6·25	6·25	8·5	13
Ideal Efficiency, per cent.	35·1	35·6	39·5	44·1
	lb. per sq. in.			
Gross I.M.E.P.	142·0	93·8	104·0	116·0
Pumping M.E.P.	2·3	3·0	3·0	3·0
Net I.M.E.P.	139·2	90·8	101·0	113·0
Friction M.E.P.	25·5	25·5	25·5	25·5
Brake M.E.P.	113·7	65·3	75·5	87·5
Relative B.H.P., per cent.	100·0	57·4	66·4	77·0

TABLE IV.—*Effect of Variations in Calorific Value of Gas.*

Gas Analysis :—				
CO_2 per cent.	6	5·5	5	3
CO "	22	23	25	30
H_2 "	5	8	12	15
CH_4 "	0	0·5	1	1
N_2 "	67	63	57	51
Net Cal. Value, B.Th.U. per cub. ft., 60 deg. F., 30 in. Hg, dry	84	100	122	146
Air : Gas Ratio	0·64	0·79	0·98	1·17
Heat Content of Air : Gas Mixture, B.Th.U. per cub. ft.	51·1	56·0	61·7	67·4
Ideal Efficiency (C.R. = 6·25), per cent.	36·5	36·0	35·6	34·7
Gross I.M.E.P. lb. per sq. in.	79·7	86·1	93·8	99·9
Pumping M.E.P. "	3·0	3·0	3·0	3·0
Net I.M.E.P. "	76·7	83·1	90·8	96·9
Friction M.E.P. "	25·5	25·5	25·5	25·5
Brake M.E.P. "	51·2	57·6	65·3	71·4
Power Relative to Petrol (C.R. = 6·25 for petrol and gas), per cent.	45·0	50·6	57·4	62·8
Power Relative to Petrol (C.R. = 6·25 for petrol, 8·5 for gas), per cent.	52·6	58·8	66·4	72·3

The ideal efficiencies and the various mean effective pressures have been calculated for the following conditions :—(*a*) With petrol as fuel in an engine of 6·25 to 1 compression ratio, for which the heat release is 93·4 B.Th.U. per cubic foot at 60 deg. F. and 30 in. of mercury, assuming the lower calorific value of petrol to be 18,870 B.Th.U. per pound, and (*b*) for producer gas containing 5 per cent. CO_2, 25 per cent. CO, 12 per cent. H_2, 1 per cent. CH_4, and 57 per cent. N_2, for which the lower calorific value is 122 B.Th.U. and the heat release 61·7 B.Th.U. per cubic foot of gas and air mixture at 60 deg. F. and 30 in. of mercury. The theoretical ratio of air to gas by volume is 0·977. Calculations have been made for engines using producer gas at compression ratios of 6·25, 8·5, and 13. The temperature of the fuel and air mixture entering the manifold was assumed to be 60 deg. F. for petrol and 68 deg. F. for gas. The pressure at the beginning of the suction stroke in the engine was assumed to be 13·7 lb. per square inch absolute for petrol and 13·5 lb. per square inch absolute for gas. The ideal efficiencies and the various mean effective pressures are given in Table III, which also shows the brake horse-power developed when using gas, as a percentage of the power which would be developed by a similar size of petrol engine at a compression ratio of 6·25 to 1. Fig. 2, page 61, shows the pressure-volume diagrams, curve *a* being for petrol at a compression ratio of 6·25 and curves *b* and *c* for producer gas at compression ratios of 6·25 and 8·5, respectively. The areas enclosed by the diagrams represent the indicated horse-powers, and it should be noted that the relative indicated horse-power on producer gas is greater than the relative brake horse-power with this fuel, since the constant friction horse-power results in a lower mechanical efficiency with producer gas.

TABLE VII.—*Effect of Gas and Air Temperatures.*

Temperature of Gas (deg. C.) and Air Mixture (deg. F.)	10 / 50	20 / 68	30 / 86	40 / 104	50 / 122
lb. per sq. in.					
Gross I.M.E.P.	97·8	93·8	91·1	87·9	85·1
Pumping M.E.P.	3·0	3·0	3·0	3·0	3·0
Net I.M.E.P.	94·8	90·8	88·1	84·9	82·1
Friction M.E.P.	25·5	25·5	25·5	25·5	25·5
Brake M.E.P.	69·3	65·3	62·6	59·4	56·6
Power Relative to Petrol, per cent. (C.R. 6·25 for petrol and gas)	61·0	57·4	55·0	52·3	49·8

The loss in power resulting from the conversion of a petrol engine of given compression ratio to the use of producer gas as a fuel is due to the following factors :—(1) The low calorific value of the gas and air mixture admitted to the cylinders. The heat content of this mixture is about 62 B.Th.U. per cubic foot at 60 deg. F. and 30 in. of mercury, whereas the corresponding figure for petrol and air mixtures is about 95 B.Th.U. per cubic foot. This reduction is due to the relatively large volume of the charge occupied by the fuel, which is about 50 per cent. for gas, compared with about 2 per cent. for petrol, and thus considerably limits the amount of air which can be drawn into the cylinder without supercharging. (2) The products of combustion from a mixture of producer gas and air occupy about 8 per cent. less volume than the original charge. This is due to the fact that when both carbon monoxide and hydrogen are burnt, the volume of CO_2 or H_2O vapour produced is equal to that of the original fuel, and the volume of oxygen involved in the combustion process disappears. In the case of methane, there is no change in the volume of the products after combustion, while with the higher hydrocarbons, such as petrol vapour, there is an increase in the volume of the products of combustion amounting to about 7 per cent. This change in volume has a direct effect upon the power produced in a cylinder of a given size. (3) The weight of gas and air mixture drawn into the cylinder is appreciably reduced if the charge is supplied at a high temperature or at a pressure below atmospheric, owing to the pressure drop through the producer and filtering system. On the other hand, with petrol there is a cooling effect due to the latent heat of vaporisation of the liquid, which may even need to be assisted to some extent by heat transfer from the exhaust to the inlet manifold. In a producer-gas driven engine, this heat transfer should be avoided and ample cooling facilities provided, so that the gaseous charge is reduced to as near atmospheric temperature as possible. It is also evident that the pressure drop through the producer and filtering system should be reduced to a minimum. (4) In contradistinction, the ideal efficiency at the same compression ratio is slightly higher for producer gas than for petrol. This effect is due to the lower temperature obtained with gas and consequently less change in the specific heat of the gases.

TABLE V.—EFFECT OF INLET PRESSURE.

Pressure at beginning of compression, lb. per sq. in. abs.	11·5	12·5	13·5	14·5	16·5	18·5	20·5
Pressure relative to atmosphere, in. Hg	−6·5	−4·5	−2·4	−0·4	+3·7	+7·7	+11·8
Gross I.M.E.P., lb. per sq. in.	75·2	84·5	93·8	103·1	121·9	141·1	159·3
Pumping M.E.P. "	5·0	4·0	3·0	2·0	0	−2·0	−4·0
Net I.M.E.P., "	70·2	80·5	90·8	101·1	121·9	143·1	163·3
M.E.P. to supercharge, "	—	—	—	1·6	5·6	9·6	13·6
Friction M.E.P., "	25·5	25·5	25·5	25·5	25·5	25·5	25·5
Brake M.E.P., "	44·7	55·0	65·3	74·0	90·8	108·0	124·2
Power relative to petrol, per cent.	39·3	48·4	57·4	65·0	79·8	95·0	109·2
Volumetric efficiency, charge at 60 deg. F. and 30 in. mercury, per cent.	63	71	78	—	—	—	—

TABLE VI.—EFFECT OF PETROL ADDITION.

Proportion of full-power petrol	0	0·1	0·2	0·3	0·4	1
Proportion of full-power gas	1	0·9	0·8	0·7	0·6	0
Gross I.M.E.P., lb. per sq. in.	93·8	98·1	103·0	107·8	112·6	142·0
Pumping M.E.P., "	3·0	3·0	3·0	3·0	3·0	2·8
Net I.M.E.P., "	90·8	95·1	100·0	104·8	109·6	139·2
Friction M.E.P., "	25·5	25·5	25·5	25·5	25·5	25·5
Brake M.E.P., "	65·3	69·6	74·5	79·3	84·1	113·7
Power relative to petrol (C.R. 6·25 for petrol and gas), per cent.	57·4	61·2	65·5	69·7	74·0	100·0
Power relative to petrol (C.R. 6·25 for petrol, 8·5 for gas), per cent.	66·4	71·1	75·7	80·1	84·4	—

Effect of Variations in the Calorific Value of the Gas.—The calorific value of producer gas may be considerably improved by injecting steam with the air, this steam being reduced to hydrogen by the incandescent carbon. By this means, the hydrogen content of the gas may be increased from under 5 per cent. to as much as 15 per cent., and the nitrogen content of the gas is simultaneously reduced. Typical analyses of various qualities of gas produced from cokes or anthracite are shown in Table IV, from which it is seen that when the calorific value of the pure gas is almost doubled, the increase in calorific value of the mixture of gas and air, although much less, is still significant. The mean effective pressures and the relative powers are given in the same table. These calculations show that a substantial benefit should be obtained by using a gas of improved calorific value.

Effect of Variation in the Gas Inlet Pressure.—Experimental evidence shows that the restriction to gas flow caused by the producer and the filters results in a considerable reduction of the volumetric efficiency, compared with the petrol engine. The figures in Table V show the effect of reducing the pressure at the beginning of the compression stroke, due to resistance to gas flow, and also the improve-

ment to be expected by supercharging the mixture of gas and air. In the latter case, a deduction has been made for the energy required to supercharge the gases with an efficiency of 50 per cent. The compression ratio of the cylinder is 6·25. The relative power figures show the extreme importance of reducing to a minimum the pressure drop through the producer and filtering system. By increasing the initial pressure at the beginning of compression to about 5 lb. per square inch above atmosphere, the power developed by an engine using producer gas of calorific value 122 B.Th.U. per cubic foot will be brought up to a level equivalent to that attained in the same engine when using petrol without supercharging. This theoretical result agrees very well with the results of experiments made by the French Ministry of Agriculture.

Effect of Gas Temperature.—An efficient gas-cooling system should reduce the gas temperature to about 50 deg. C. If gas at this temperature is mixed with an equal volume of air at 20 deg. C., the temperature of the mixture will be approximately 35 deg. C. Frequently, the temperature of the gas and air mixture will be below this value, and is only likely to exceed it when the vehicle is climbing a long hill in low gear. The figures given in Table VII show the power developed with gas and air mixtures at various temperatures, the compression ratio of the engine being 6·25, the pressure at the beginning of compression 13·5 lb. per square inch absolute, and the gas having a calorific value (at 60 deg. F. and 30 in. of mercury) of 122 B.Th.U. per cubic foot. These figures may be compared with those given in Table V of the effect of reduced inlet pressure, and show that excessive pressure drop through the producer and filter will cause a greater power loss than any rise in temperature of the gas and air mixture that is likely to take place.

Addition of Petrol.—A simple method of increasing the power when running on gas is to add a certain amount of petrol to the mixture at full throttle. The figures in Table VI show the power increase with varying additions of petrol. It should be noted, however, that when petrol is added, the amount of gas at full throttle will have to be reduced, in order that there may be sufficient air present for the complete combustion of both fuels.

Conclusions.—Theoretical considerations have shown that when a petrol engine is converted to use producer gas as a fuel, there is an unavoidable decrease in power of the order of 40 per cent. to 50 per cent., if no modification is made to the engine by altering the compression ratio or by supercharging. This power loss may be reduced in the following ways:—(1) By using an entirely new engine of approximately double the capacity of the original petrol engine, which will then develop the same power as the smaller petrol engine. (2) By increasing the compression ratio. If the engine is still to be capable of being run for short periods on petrol, it is not in general feasible to increase the compression ratio beyond 8·5. At this compression ratio, the brake power developed on producer gas will be about 15 per cent. more than the same gas would give at a compression ratio of 6·25, and about 24 per cent. more than would be obtained at a compression ratio of 5·6. (3) By supercharging the gas and air mixture it would be possible to increase the power developed on gas up to that developed with petrol. (4) The addition of petrol vapour will enable the power loss to be made up for short periods, but cannot, of course, be considered as a solution of the problem of using producer gas.

Acknowledgment is made to the Council of the British Coal Utilisation Research Association for permission to publish these calculations, and the results of the engine bench tests made subsequently will be published later.

CONTROL OF EXPORTS OF CERTAIN COMMODITIES.—The Board of Trade has issued the Export of Goods (Control) (No. 3) Order, 1941, which came into force on January 23. Under the terms of this Order a licence from the Board of Trade will be required to export, to any destination, aluminium leaf and foil in all forms, whether or not backed with other material; dairy machinery; and certain forms of glass and glassware, including bulbs and shells for electric lamps and wireless valves, phials, bottles and tubular containers and tubing.

LITERATURE.

Radio-Frequency Measurements. By DR. L. HARTSHORN. Monographs on Electrical Engineering: Volume X. London: Chapman and Hall, Limited. [Price 21s.]

ELECTRICAL measurements within the radio-frequency range—between, say, 10 kilocycles and 100 megacycles per second—present numerous difficulties. Nothing is better calculated to reveal their extent and reality than the attempt to measure the same quantity by two essentially different methods, as is suggested by the author at the close of this book. It is not difficult to assemble apparatus and take measurements; the difficulty is to be sure that what is measured is what it was intended to measure. Even with apparatus as simple, and a method of measurement as straightforward, as possible, special precautions are still needed before it can be claimed that the measurement made relates exclusively to the component under test, and not in part to the remaining circuit components or even to objects external to the circuit but so located in relation to it as to be coupled with it. E.m.f.'s of self and mutual inductance affect the current travelling along every conducting path, and displacement currents traverse all dielectric materials. Their relative importance increases as the frequency rises, while at the same time the quantities that determine reactance become less definitely localised. The only alternatives are either to minimise these causes of disturbance by careful design, or to render them sufficiently definite that their values can be ascertained by experiment or derived by calculation.

In a field so full of pitfalls, the expert guidance provided in this book is very welcome. Dr. Hartshorn divides his treatment into three parts dealing, respectively, with principles, apparatus and methods. Part I contains three chapters devoted to the principles underlying resonance and bridge methods. In chapter 1, the parameters characterising the several types of circuit element are defined; the behaviour of these elements when combined in various simple circuits is investigated; and their mutual relationship in coupled circuits is discussed. Chapter 2 describes the general technique of high-frequency measurements, and compares the resonance and bridge methods. Despite the superiority of null methods over deflectional methods, the irreducible simplicity of the single-mesh L R C resonating circuit, in which the unknown component can be substituted in place of the standard, and resonance re-established by adjustment of the frequency or some other circuit parameter, has much to recommend it. The conditions governing current and voltage resonance in both the series and parallel circuit arrangements are considered, together with the effect of dielectric loss in the condenser. Simple resonance curves of this kind are characterised by a single hump, in which the ratio of height to breadth increases with the sharpness of the resonance. The curves for voltage resonance and parallel-current resonance are shown to be symmetrical even when leakage is present. As some difficulty is experienced in locating the summit of such a hump with accuracy, it is generally preferable to obtain readings of corresponding points of equal ordinate on either side of the peak in regions where the slope is steep. Another group of methods for the measurement of impedance can be based upon the study of the reaction of the resonating circuit on the source from which it is energised. It is unfortunate that the suffixes *p* and *s* should here be used to distinguish parameters relating to the primary and secondary circuits, when they have been previously employed to denote parameters in parallel and series combinations.

Chapter 3 contains an admirably thorough exposition of the general principles of screening, with particular reference to the radio-frequency bridge. Electrostatic screening is based on the fact that no capacitative coupling can exist between two circuits, one of which is wholly inside and the other wholly outside a closed hollow conductor. Complete enclosure is generally impracticable, but the casing should extend as far round the component as is feasible and should be maintained at a definite potential (usually, it is earthed). Electromagnetic screening can likewise be secured by surrounding the coil with a metal shield; though this need not be earthed, it must present as low a resistance as possible to eddy-current circulation. The advantages of the symmetrical type of bridge are clearly pointed out and the importance of the Wagner earth connection emphasised. Valuable practical hints on the rational procedure for converging upon the bridge balance point are also given.

Part II is concerned with equipment and apparatus. It consists of five chapters, the first two of which deal with generators and detectors. After describing the mode of operation of typical valve oscillator circuits of proved usefulness, the factors governing their stability and the purity of their wave form are considered. Instruments for the detection and measurement of radio-frequency currents fall into two classes, namely, those suitable for null methods and those required to indicate a magnitude, though not necessarily in absolute value. Representatives of each class of instrument are described, and their advantages and limitations discussed. The remaining three chapters are devoted to standards of capacitance, resistors, and standard inductors. The special precautions demanded in the construction of these fundamental components, so that they shall have the value, or cover the range of values, required, and shall conserve these values more or less permanently under normal operating conditions, are adequately covered.

The actual methods of measurement are dealt with in Part III. Measurements of capacitance, inductance, resistance, power factor and decrement by the resonance method are discussed first, after which the use of the various types of bridge is described. Sufficient detail is given to render this section serviceable as a guide to laboratory procedure. Points liable to be overlooked by the inexpert experimenter are brought out, and, though some of them may look obvious or even trivial on paper, neglect of them often causes disproportionate delays in carrying out the experiments. The concluding chapter is devoted to methods available for measurements at frequencies so high that the assumption that the current has the same value throughout the whole of its path is no longer valid.

Only a master of his subject could expound it with such elegance and clarity as Dr. Hartshorn has done in this noteworthy book. His contribution more than maintains the high standard set by previous volumes in this series.

Chrome Ore and Chromium. By ROBERT ALLEN and G. E. HOWLING. London: The Imperial Institute. [Price 2s. 6d. net.]

AMONG the many metals which are of vital importance in both peace and war, chromium takes a high place. This opportune monograph, one of the well-known series on mineral resources issued by the Imperial Institute, covers every aspect of the nature, occurrence and utilisation of chrome ore and chromium, with particular reference to the extensive deposits of high-grade ore which are available within the Empire. The significance of the mineral may be gauged from the fact that the world's production rose, between the close of the war of 1914-18 and the outbreak of the present conflict, from less than a quarter of a million to more than a million tons. The chief producers, at the time when hostilities commenced, were Turkey, Southern Rhodesia, South Africa, Russia and Cuba, more than two-thirds of the output being supplied by British-controlled companies.

The principal employment is for metallurgical purposes and in the production of high-duty refractory linings for furnaces, but chromium salts for tanning, and various chemical applications, as well as chromium plating, are important uses, although the quantity of ore required for these is relatively small. All of these uses are dealt with in the monograph, but the greater part of the book is devoted to the distribution of the ore, and the processes of mining and dressing, with some notes on marketing and prices, and production statistics. There is a detailed bibliography, classified under the main headings of "General," "Uses," "Chrome Ore in the British Empire" and "Chrome Ore in Foreign Countries."

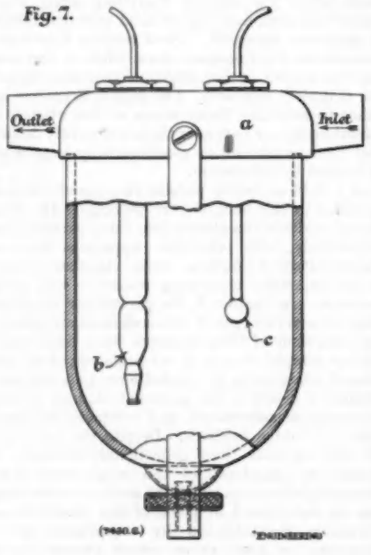
THE DETERMINATION OF HYDROGEN-ION CONCENTRATION.

(*Concluded from page* 23.)

IN many processes it is desirable to employ automatic control of *p*H values, incorporating means by which acids or bases can be automatically added to solutions to maintain constant conditions. For such purposes the electrode may be arranged for immersion in a vessel through which the solution under test passes in a continuous flow, as illustrated in Fig. 7, on this page. Alternatively, dip-type electrodes, for immersion directly into the solution, can be employed. In Fig. 7, *a* is a watertight sealed cap, *b* a standard calomel electrode, and *c* a standard glass electrode. For automatic control, the *p*H meter is replaced by a recording potentiometer fitted with a special control mechanism. An example of such an instrument is shown in Fig. 8, opposite. The recording *p*H controller is seen on the left of the illustration, and, on the right, a continuous-flow antimony-calomel electrode system. The controller operates in the following manner: the varying e.m.f. from the measuring electrodes is applied to the potentiometer circuit, the potentiometer being balanced automatically by a device which also provides motive power for the recording pen. Thus, for each variation in the electrode e.m.f. and the corresponding balance of the potentiometer, the recording pen is moved a proportionate amount across the chart. This operation is effected by a galvanometer in the recorder, the pointer of which carries at its extremity a ball which is clamped at regular intervals between two discs. These discs are on a spindle which, when rotated, moves a contact over a slide wire and also adjusts the position of the recording pen. If, at one of the clamping intervals, the galvanometer circuit is out of balance, a simple cam device causes two scissors arms to move the ball back to the zero position, thus rotating the discs, moving the recording pen, and restoring the balance by moving the contact along the slide wire. The mechanism is driven by an electric motor suitable for standard voltages. Switches are incorporated in the instrument and are arranged automatically to operate valves, should the recorded *p*H concentration vary beyond predetermined limits. These valves are arranged to add agents to the controlled media, thus maintaining its concentration at the desired *p*H value. Fig. 9, opposite, shows a typical *p*H-recording installation on a nickel-plating vat of the continuous-conveyor type, at the works of a motor-car manufacturing firm. It comprises a recording potentiometer, together with a continuous-flow electrode system as described above. If the *p*H value exceeds 5·8, sulphuric acid is added, and if it falls below 5·5, nickel carbonate is added. It is, perhaps, hardly necessary to emphasise that each *p*H-control installation calls for individual consideration in order to ensure maximum efficiency.

Metallurgical Applications.—In almost every solution used in connection with electro-deposition processes, *p*H determination and control are factors of major importance. Early research in this connection was carried out by M. R. Thompson nearly 20 years ago,* and since that date many papers have been published revealing the significance, and, in many plating processes, the necessity, of *p*H control. Slight changes in the acidity of baths employed for the electro-deposition of metals, in many cases, have a serious effect upon such matters as the appearance, hardness, tarnish-resistance, and period of treatment. Nickel-plating solutions are usually maintained between 5·2 *p*H and 6·8 *p*H; in barrel plating the best value is slightly above 6 *p*H, while acid zinc-plating solutions should be maintained between 4 *p*H and 5 *p*H. In a paper published recently,† descriptions are given of rapid methods for heavy nickel plating and of the effect of *p*H upon the process. It is stated that heavy nickel deposits of the order of 0·005 in. are being applied industrially for resistance to wear or as a combined preventive against corrosion and wear. Deposits of from 0·01 in. to 0·03 in. are also needed for building up worn or undersized parts, while, in some cases, deposits up to 0·1 in. or 0·2 in. thick have been deposited for building up large worn parts and for electro-forming complete pieces. The outstanding advantage of electro-deposited nickel lies in the possibility of varying the physical properties of the deposit over an extremely wide range. In this connection, it has been shown that the *p*H value of the solutions is a most important factor in determining these properties. In many applications, the nickel may have to be machined, and, in others, subjected to severe wear. Sufficient strength and toughness, therefore, are the outstanding requirements to ensure satisfactory results under such conditions. Ductility and hardness may also be required to fall within given limits. Tensile strength and hardness increase with rising *p*H, and, by comparatively simple changes in plating conditions, the tensile strength may be varied from 22 tons to 58 tons per square inch, and the hardness

Fig. 7.



can range from 125 to about 500 Brinell. To secure maximum hardness, it is stated that a *p*H of 5·2 to 5·8 is desirable. J. G. Sterling* gives the views and observations gained after 15 years' experience in the electro-deposition of nickel. He suggests that, when using the Watts hot nickel-plating solution, the *p*H value should be maintained between 4·8 and 5·8; if the *p*H falls, nickel carbonate should be added; if it rises, correction should be made by the addition of sulphuric acid.

L. E. Price and G. J. Thomas,† have carried out considerable research recently in connection with the electro-deposition of thin invisible films of beryllia or alumina on silver, in order to obtain a high degree of tarnish resistance. In this connection, it is pointed out that the *p*H values of the solutions used are of primary importance. The authors provide several interesting curves clearly indicating that the increase in electrode potential during treatment, and the *p*H value of the solution, bear a direct relationship to the degree of tarnish resistance. It is of interest to note that difficulty in repeating results in the tarnish-resistance process led the authors to a closer investigation of the methods employed, and it was found that protection could be obtained over a limited *p*H range only, namely, from approximately 5·75 to 5·85. It has been observed that, although the importance of the *p*H of alkaline plating solutions has been reported in Great Britain, the United States and Germany recently, it is remarkable that little has been published in technical journals on the significance and influence of these values. Some results of researches which have been made available, however,* show that brass baths work best within a range of *p*H values of from 9·5 to 10·2. With values of over 10·2, the deposits are discoloured, probably due to the formation of zincate. Unsatisfactory adhesion of cadmium deposits can usually be rectified by increasing the *p*H value to 12 or more, while, in copper baths, the formation of blisters can be reduced by increasing the *p*H value.

In the manufacture of paints, *p*H determination bears directly upon the covering power and colour brilliance of the finished product. Much work has been done in connection with the development of a formula which will give satisfactory results for the production of molybdenum orange pigments, and, in a recent study, it was found that the precipitation should be carried out in solutions of which the final *p*H is about 4·0 to 5·0, and the development of colour in solutions of *p*H 2·5 to 3·0. The influence of *p*H on this and other similar processes is particularly marked, either too low or too high a *p*H value producing a yellower and less desirable colour. When the *p*H value is too high there is no transformation from yellow, and when it is too low the transformation continues from yellow to red, but back to yellow again.† In the construction of pipe and boiler systems, the *p*H of the solution it is proposed to accommodate should be an important consideration in the choice of suitable metals. As an instance, in a recent article in an American contemporary, relating to feed-pump corrosion,‡ the *p*H value of the feed water is stated to be an important factor in the selection of metals for their manufacture. It has been found that carbon steel or cast iron are generally suitable for neutral or alkaline liquids; bronze, for neutral or slightly acid liquids; and special alloys, for strongly acid liquids. Having decided upon the metal to be used, and upon the limits of *p*H to which it can be exposed, it is possible to control this value within certain safe limits by the injection of various neutralising agents into the solution, thus avoiding corrosive action. Control of *p*H is also of importance in the brines of refrigerator installations, in order to minimise pipe corrosion. Reference has already been made to apparatus for automatically controlling such processes. In connection with the construction of underground metallic pipes or ducts, knowledge of the *p*H concentrations of the earth in which they are buried should prove of value. Industrial soils have been found to be mostly acid, since industrial waste materials containing sulphides often have an acid reaction, as, for example, hydrogen sulphide oxidising to sulphuric acid. Waste materials from gas-purification plants have a particular effect, as they are rich in sulphur. Special precautions also are necessary when laying metal pipes in places where formerly refuse dumps and slag heaps existed.

In solutions used for the separation of ores from foreign matter, and the separation of one ore from another, the *p*H concentration has been found to be important; Gaudin has shown,§ in connection with investigations into the effect of *p*H variation in flotation pulps containing xanthates, that chalcocite may be completely recovered within certain limits while pyrites tend to sink at a *p*H higher than 6·2. Many other examples can be quoted, and H. T. S. Britton, in his work *Hydrogen-Ions*,‖ devotes a chapter to the subject. In a book recently published by chemists of the United States Steel Corporation, entitled *The Sampling and Analysis of Carbon and Alloy Steels*,¶ an explanatory appendix is included, dealing with *p*H. It is observed therein that, throughout the methods described in the volume,

* See M. R. Thompson, "The Acidity of Nickel Depositing Solutions," *Trans. Amer. Electrochem. Soc.*, vol. 97, page 2477 (1922).

† See L. W. Eisberg, "Rapid Methods for Heavy Nickel Plating," *Monthly Review Amer. Electroplaters' Soc.*, vol. 26, page 929 (1939).

* See "Nickel Plating," *Metal Industry*, vol. 56, page 14 (1940).

† See *Journ. Inst. Metals*, vol. 65, page 247 (1939).

* See R. Springer, paper on "Electroplating Practice in Germany," presented to First International Electrodeposition Conference, London, March, 1937. See *Sheet-Metal Industries*, page 386 (April, 1937).

† See A. Linz, *Ind. and Eng. Chem.*, vol. 31, page 298 (1939).

‡ See J. B. Godshall, *Power*, page 64 (August, 1939).

§ See *Min. & Met.*, vol. 10, page 9 (1929).

‖ Chapman and Hall, Limited. Page 568

¶ Chapman and Hall, Limited. 1939.

CONTROL OF HYDROGEN-ION CONCENTRATION.

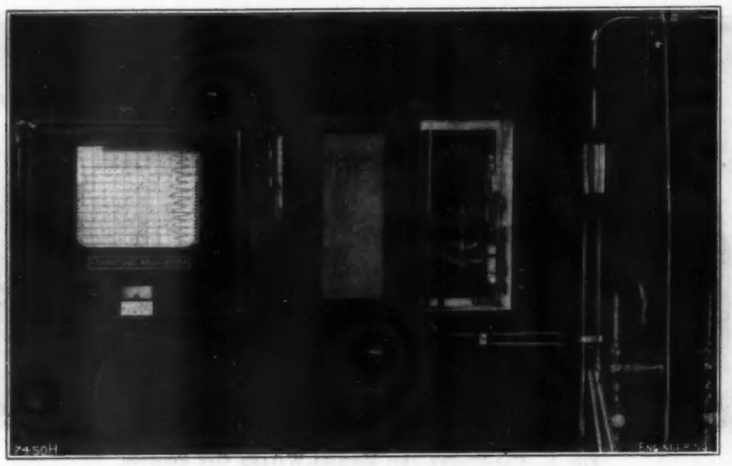


FIG. 8. RECORDING *p*H CONTROLLER AND ELECTRODE SYSTEM.

FIG. 9. CONTINUOUS-FLOW ELECTRODE SYSTEM ON NICKEL-PLATING VAT.

the *p*H of solutions appears to be a most important item in the control of the separation of various elements and compounds. Processes for the determination of manganese, chromium and other elements in steel are described, and suitable apparatus is suggested for carrying out the determinations. In Japan, much research has been carried out in connection with metallurgical analyses. In a recent paper by Hisaji Kato, published in English,* studies in the quantitative separation of metals by hydrogen sulphide are described. These studies reveal the importance of using solutions maintained within certain suitable *p*H ranges. For the separation of nickel, cobalt and zinc from manganese, a *p*H value of from 3 to 4 is recommended, while, for the quantitative separation of nickel and cobalt from manganese, a *p*H range of from 4·0 to 4·8 is advocated. Another paper in this series, also in English, deals with the quantitative separation of zinc from iron by hydrogen sulphide, and the reduced precipitation of ferrous sulphide by zinc sulphide. In this instance, the most suitable *p*H value at which the latter may be separated is stated to be 2·4. In conclusion, it may be pointed out that other applications of *p*H determinations are constantly being revealed. There are many applications in fields associated with engineering, for example, various sewage-treatment, water-purification and paper-making processes, in which determinations of *p*H values are already established as routine procedure.

We are indebted to Messrs. Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1, for the drawings and photographs from which our illustrations have been prepared.

* *Sci. Rep. Tohoku Imperial University*, vol. 28, page 500 (1940).

235-B.H.P. GAS ENGINE AND CRANKLESS GAS BOOSTER.

THE gas-boosting plant illustrated in Figs. 1 and 2, on page 66, and in Figs. 3 to 8, Plate V, is one of six sets nearly completed by Messrs. The National Gas and Oil Engine Company, Limited, Ashton-under-Lyne, for the Australian Gaslight Company, Sydney, New South Wales. Each set comprises a five-cylinder gas engine, developing 235 brake horse-power continuously and a 10 per cent. overload for one hour, the speed being 600 r.p.m. The engines are coupled directly to crankless gas boosters, that is, compressors of the swash-plate type, supplied by Messrs. George Waller and Son, Limited, Phœnix Iron Works, Stroud, Gloucestershire. The booster was originally designed by the late Mr. A. G. M. Michell, the inventor of the well-known thrust bearing, and has been developed by Messrs. Waller under the name of the "Michell-Waller" gas booster. The object of employing the swash-plate principle is to provide a machine which shares with the turbo-type of booster a satisfactory dynamic balance, and is capable of running at high speeds and giving large outputs in a small space, while, unlike the turbo type, its mechanical efficiency remains the same at low speeds as at high speeds. Compared with the reciprocating type of booster, it is equally positive in action, and compared with the fan type, two or more crankless boosters can be run in parallel without loss of efficiency, which, it is stated, is not the case with the fan-type of compressor.

The engines are of the "HAG" type. A complete installation of engine and booster is shown in Fig. 1, a view of the engine only, taken from the opposite side and mounted on the test bed, being reproduced in Fig. 2. The longitudinal section, Fig. 3, illustrates the main features of the engine. As already stated, the engine has five cylinders, each cylinder having a bore of 10 in., a piston stroke of 13 in., and developing a load of 46 brake horse-power continuously. It will be clear from Fig. 3 that the engine operates on the four-stroke cycle, and ignition is effected by high-tension sparking plugs. It may seem from this figure that the crankshaft is unduly heavy for the piston load, but it should be explained that the main castings, etc., are used also for a compression-ignition engine in which the load is greater. Fig. 3, moreover, is typical of the internal structure and does not conform in all its details with Figs. 1 and 2. It will be noticed, in particular, that it illustrates a six-cylinder engine.

Dealing with the external features of the engine first, it will be evident from Fig. 1 that the control consists of two handwheels at the flywheel end. Initial movement of the larger of these wheels starts the engine by admitting compressed air to all the cylinders, while further movement, once the crankshaft starts to rotate, cuts off this air supply and opens the gas control valve, thus putting the engine on to fuel. The small lever to the right of the handwheels actuates the main air valve, and this lever is put to the full-open position when the governor has taken control of the engine speed and of the gas and air mixture. Movement of the larger handwheel to the "stop" position shuts off the gas, without, of course, opening the compressed-air valve, and brings the engine to rest. The smaller handwheel regulates the tension of the governor spring and enables the speed to be varied from the maximum down to half the maximum. The starting system gives very simple operation and excessive pressures are avoided by the gradual entry of the fuel into the cylinders after the compressed air has been shut off.

The external rectangular pipes seen on the bedplate in Fig. 1 call for comment, but their purpose is better understood by reference to Fig. 2. These pipes are the cooling-water conduits. The discharge from the circulating pump is seen in the bottom right-hand corner of Fig. 2. The water passes by way of a short pipe into the bedplate, through which it traverses the box-section main bearing cross member at the right of Fig. 3. From this passage it is conveyed to the next cross-member by the short external pipe to the right of Fig. 1, and then passes through the cross-members of five main bearings, the sixth main bearing not having a water passage. On leaving the fifth bearing the external pipe is first led upwards and then along the cylinder casing as seen in Fig. 2, branches at each cylinder providing passages to the jackets. The horizontal pipe is led downwards again at the pump end of the cylinders to join the delivery pipe from the pump and a valve will be noticed at the point of junction. This valve constitutes a by-pass, so that when starting up the engine the cooling water can be directed straight to the cylinder jackets until the lubricating oil has reached the best operating temperature. The flow is then diverted, either wholly or in part, according to the running conditions, to the main bearing passages. The oil is thus kept at the desired temperature by passing through the water-cooled main bearings, no independent oil-cooling system being required. The cooling water, after leaving the cylinder jackets, passes through the

cylinder heads to the jacket of the exhaust manifold. The outlet temperature from each cylinder can be regulated.

The gears seen below the exhaust manifold in Fig. 2 are the throttle valves controlling the gas supply and the combustion-air supply to each cylinder. They are actuated by a centrifugal governor which is driven from the camshaft and is provided with means for adjustment so that the speed can be varied while the engine is running. The governing is on the quantity system with individual mixture control to each cylinder. The governor casing can be identified just above the flywheel in Fig. 1, the gas and air valve control shaft in Fig. 2, and the governor drive is shown on the right in Fig. 3. This view shows, also on the right, the interesting two-stage drive to the camshaft. The first drive is by means of a single heavy roller-chain from a sprocket wheel on the crankshaft to one mounted on a swinging arm. The sprocket wheel on the countershaft is bolted to a duplex roller-chain sprocket wheel, whence the drive is transmitted to the camshaft. The single chain can, obviously, be tensioned by altering the position of the swinging arm, but unless other means were provided this movement would put excessive strain on the duplex chain. The two sprockets on the swinging arm are, therefore, mounted eccentrically on their countershaft so that, on rotating the eccentric bush by means of a worm adjustment, both chains can be suitably tensioned.

It will be clear from Fig. 3 that the high situation of the camshaft results in short and stiff push-rods, with reduced inertia forces, for operating the valves, which can be seen on the left of this figure. Both inlet and exhaust valves are housed in removable cages held down by loose flanges and operate directly above the pistons. The inlet valves are double-seated, gas being admitted above the top disc and combustion air above the bottom disc. All the valve spindles are of heat-resisting steel, and the faces and cage seatings are Stellited. Double springs are fitted to both valves and both cages are water cooled. As already stated, ignition is effected by sparking plugs fed from a high-tension magneto. The magneto is driven through gearwheels at the end of the camshaft and is not indicated in Fig. 3. The gear and bearings are pressure lubricated. The camshaft bearings and other mechanism are, of course, similarly lubricated, the oil pressure ranging between 20 lb. and 25 lb. per square inch. The gear-type oil pump, driven from the crankshaft, is seen to the left of Fig. 3. It is provided on the delivery side with a filter which is readily cleaned by turning the filtering element by a handwheel.

The general construction of the engine may be now briefly dealt with. As seen in Fig. 1, the engine and booster are mounted on a common two-part bedplate with a pedestal bearing between the flywheel and the spring-type flexible coupling connecting the two shafts. The engine bedplate is a single casting with its top flush with the crank axis. The main bearings have round-backed steel shells, lined with white metal, so that they can be removed without lifting the crankshaft. The bearing caps are of cast steel. The cylinder casting is also in a single piece and, as will be evident from Fig. 1, is closely bolted to the bedplate to ensure rigidity. The cylinder liners are of the wet type, held down against a joint at the top by the cylinder heads and free to expand at the bottom end. All the liners are interchangeable.

The pistons have three pressure rings and one scraper ring above the gudgeon pin and one scraper ring on the skirt. They are ground externally and are interchangeable. The gudgeon pin is of the floating type and is case-hardened and ground. The connecting rods are of H-cross section, made from Siemens-Martin acid steel. The small end is fitted with a nickel-phosphor-bronze bush. The big end is of the marine type with four bolts and is white-metal lined. The crankshaft is machined from a solid forging of Siemens-Martin acid steel, the crank pins being bored out. The flywheel is of the disc type with a rim proportioned to give a very small speed fluctuation. The boss is bolted between the flanges of the crankshaft and the driven shaft.

The engines are tested as completed in the presence of the consulting engineer to the purchasers. The results of one of these tests are plotted in Fig. 8, Plate V. The fuel used was town's gas having a net calorific value of 435 B.Th.U. per cubic foot at a temperature of 60 deg. F. and a pressure of 30 in. Hg. The rated constant output was 235 brake horse-power. In examining the curves of Fig. 8, it may be noted that the exhaust temperature is very low considering the fairly high speed. At the maximum output of 250 brake horse-power, for instance, which is equal to 65 lb. per square inch B.M.E.P., the exhaust temperature is only 840 deg. F. The fuel consumption at full load is low, this being 8,600 B.Th.U. per brake horse-power hour, corresponding to 29·5 per cent. thermal efficiency calculated on the net calorific value of the gas. Following this curve farther to the right, viz., to the maximum load, it is seen that it is still falling, the consumption at this rate being 8,400 B.Th.U. per brake horse-power hour, or 30·2 per cent. thermal efficiency. In the other direction, the half load consumption is seen to be 11,600 B.Th.U. per brake horse-power hour, which is considered very satisfactory for a light load.

At a speed of 600 r.p.m. the booster is designed for an output of 425,000 cub. ft. of free gas per hour, against a pressure of 200 in. water gauge. The output of the blower is controlled by the speed of rotation and for this reason a wide speed variation is required from the engine. By manipulation of the control handwheel the engine speed can be reduced to 250 r.p.m. with a corresponding reduction of the booster output. Three diagrammatic sectional views of the booster are given in Figs. 4 to 6, Plate V, in order to illustrate the principles rather than the details of design. These views show a machine having 8 cylinders, whereas the boosters now under consideration have 12 cylinders, arranged in two groups of six at both sides of the swash-plate. The cylinders are double-acting and are 11 in. in internal diameter by 9 in. stroke. Each pair of opposite cylinders has a common piston rod which has a notch in the centre embracing the edge of the swashplate, both surfaces of which are plane and parallel. Rotation of the swashplate, therefore, results in reciprocation of the piston rods by an amount depending on the angle the surfaces make to the vertical plane, which angle is usually 22½ deg.

There are two valves attached to the shaft, one for each group of six cylinders. They are cylindrical, and, at first sight, may appear from Fig. 4 to be piston valves. They have, however, rotary instead of reciprocating motion, the connection between the suction and delivery branches of the booster and the cylinder ends being made by coincidence of ports in the valves with ports in the cylinders as rotation takes place. Thus, referring to the two top cylinders in Fig. 4, it will be seen that there is communication between the left-hand side of both pistons and the delivery branch in the base, this communication being made through an annular passage in the valve at the right hand and past the ported edge of the valve at the left hand. Conversely, there is communication between the right-hand side of both pistons and the suction branch, the flow taking place round the body of both valves. Since the swashplate and valves revolve together, the cylinders are put successively into communication with the branches at the appropriate portion of the piston stroke.

An important difficulty in swashplate machine operation is the friction between the plate and the piston rods, but, in the design now under discussion, this has been overcome by the adoption of the principle employed in the Michell thrust bearing. The method of application of the principle is shown in Fig. 7, Plate V. In this view, the notched portion of the piston rod is seen embracing the edge of the swashplate. It will be clear that the inclination of the latter relative

235-B.H.P. GAS ENGINE AND GAS BOOSTER.

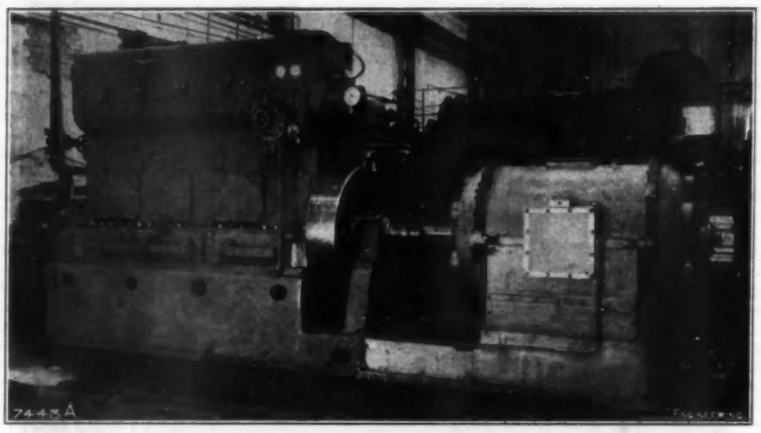


FIG. 1. GAS-ENGINE AND MICHELL-WALLER GAS BOOSTER.

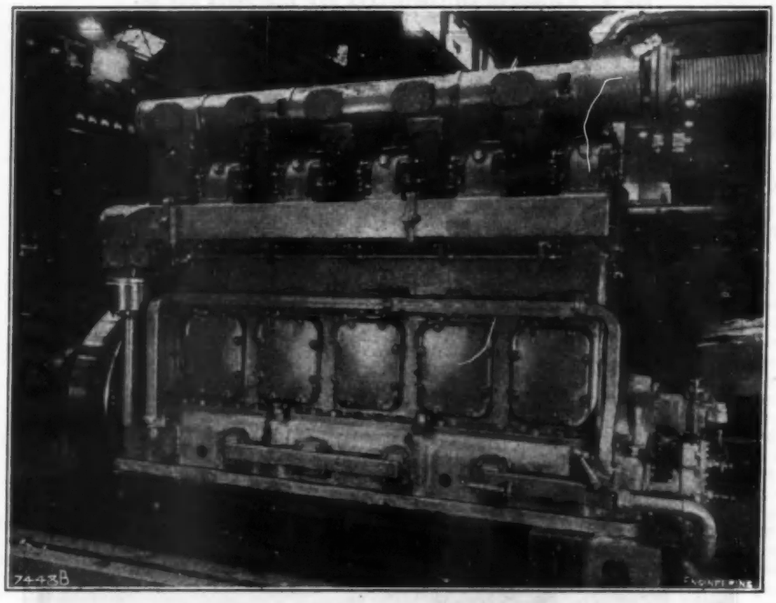
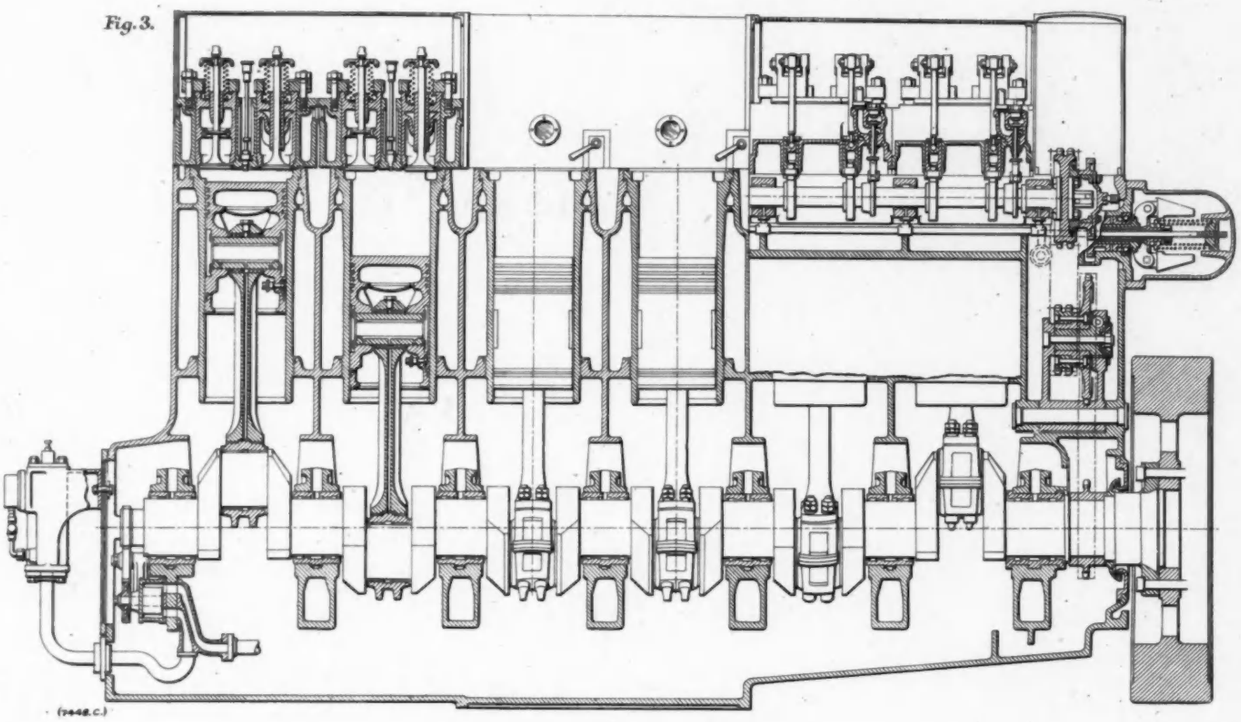


FIG. 2. 235-B.H.P. FIVE-CYLINDER NATIONAL GAS ENGINE.

235-B.H.P. GAS ENGINE AND SWASHPLATE TYPE GAS BOOSTER.

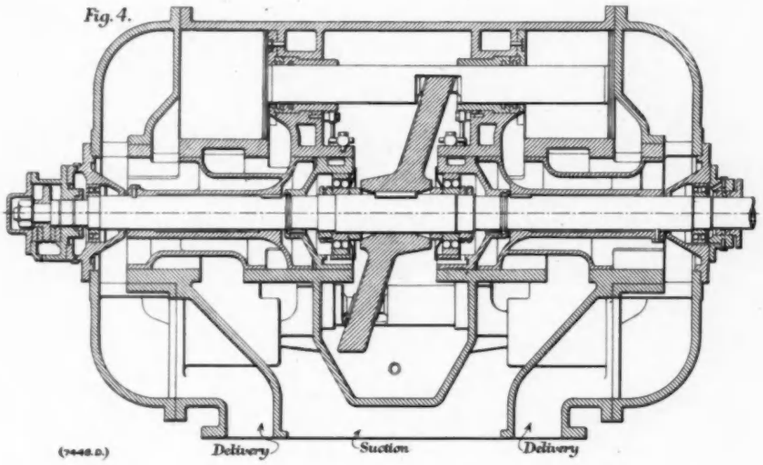
(*For Description, see Page 65*).

Fig. 3.



(7448.C.)

Fig. 4.



(7448.D.)

Fig. 5.

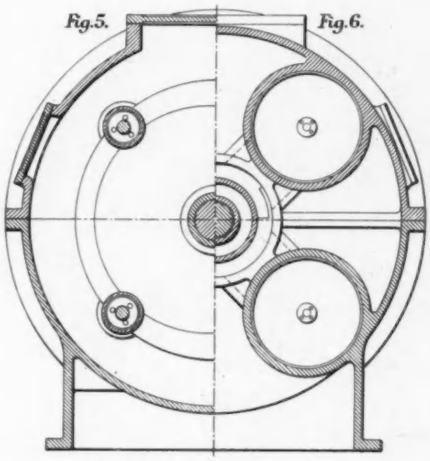
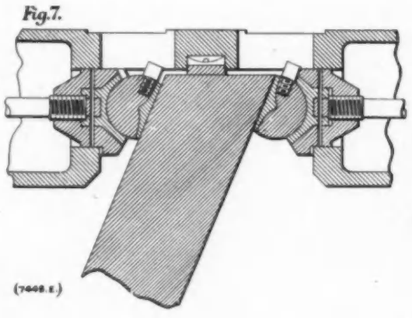


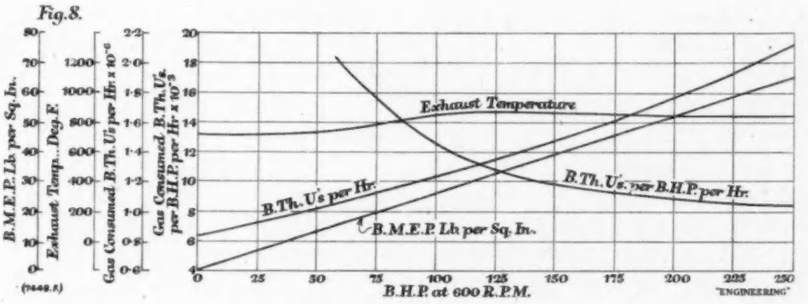
Fig. 6.

Fig. 7.



(7448.E.)

Fig. 8.


B.M.E.P. Lb per Sq. In.
Exhaust Temp. Deg. F.
Gas Consumed. B.Th.Us per Hr. x 10⁻⁶
Gas Consumed. B.Th.Us. per B.H.P. per Hr. x 10⁻³
Exhaust Temperature
B.Th.Us. per B.H.P. per Hr.
B.Th.Us per Hr.
B.M.E.P. Lb per Sq. In.
B.H.P. at 600 R.P.M.
"ENGINEERING"

(7448.E.)

(*To face page 66*).

UNIV. OF MICH.

THREE-ROLL PLATE-BENDING MACHINE.

MESSRS. JOSHUA BIGWOOD AND SON, LIMITED, WOLVERHAMPTON.

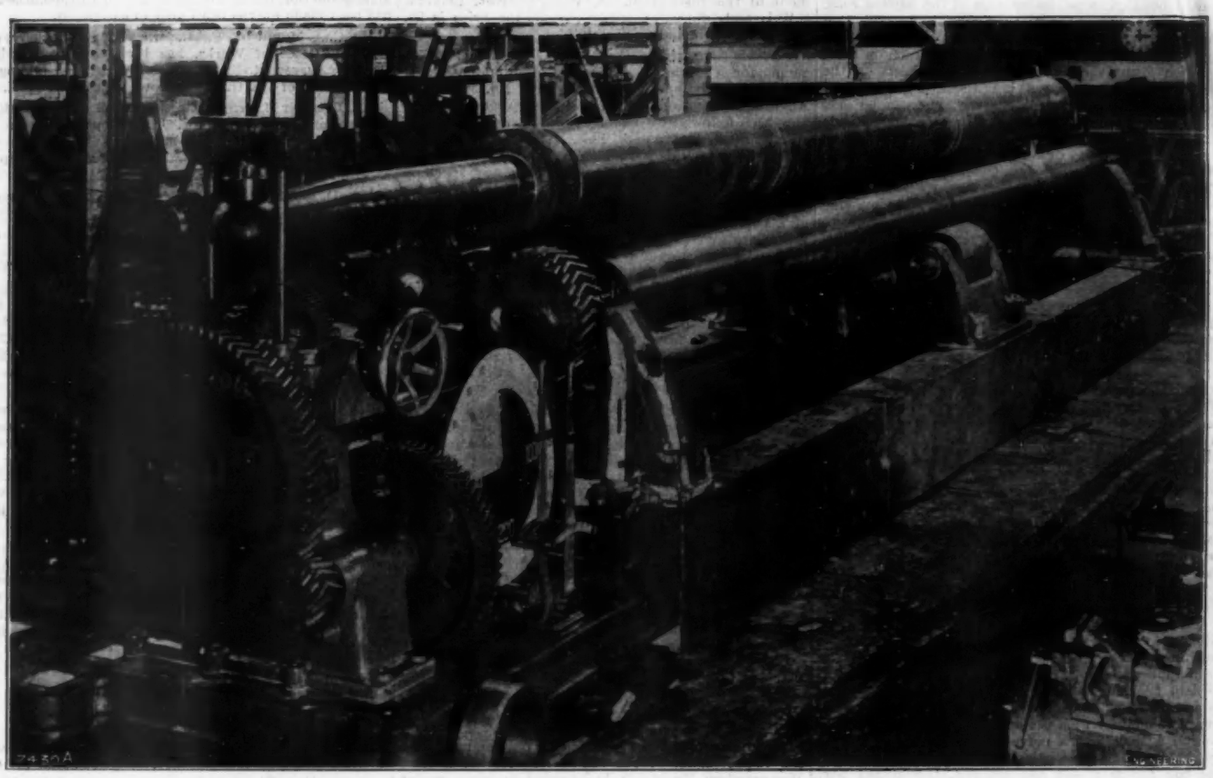


FIG. 1. MACHINE WITH LONGEST ROLLS IN POSITION.

to the piston-rod axis is constantly varying as the plate rotates, and that the plate in Fig. 7 will pass from the inclination towards the right to an equal inclination towards the left during one stroke, not one reciprocation, of the rod. The contacting surfaces of rod and plate are, therefore, fitted with ball and socket joints which permit the change in inclination. These contacting surfaces, known as slipper pads, are indicated in the figure, but it must be understood that in the circumferential sense they project considerably behind the ball surface in the direction facing the direction of rotation. Thus, if the swash plate, when viewed from right to left, is rotating in a counter-clockwise direction, the slippers at the top extend below the plane of the paper and those at the bottom project in front of it. This asymmetry results in a tilting of the slippers in the circumferential direction, and the tilt, which is very minute, permits a wedge-shaped film of lubricating oil to be formed between the pad and swashplate faces, as in the elements of the Michell thrust bearing, an example of which is employed to take the axial thrust of the booster shaft and is seen at the extreme left of the longitudinal section in Fig. 4.

The slippers are made of steel with the ball backs case-hardened and ground. The front surfaces are faced with white metal and are carefully trued and polished. The working clearance, *i.e.*, that before the pad tilts, is about 0·002 in. The cups in which the ball backs are supported are of phosphor-bronze and are carried in the piston rod, as shown, the small rods running through the centre of the piston rod providing adjustment for the slipper clearance. The small grub screws seen at the top of the ball backs engage in slots in the piston rod and are simply to prevent rotation of the slippers. The swashplate is of nickel cast iron. The periphery and the running faces are accurately ground. The pistons are of aluminium alloy and in view of the low pressure involved are of disc form. The shaft runs in four sets of ball bearings, the thrust pad end being sealed and the opposite end packed with a gland. The casing is split along the centre line, as will be clear from Fig. 1, and the suction and delivery branches are continued and led away through the bedplate common to the set.

THREE-ROLL PLATE-BENDING MACHINE.

THE three-roll plate-bending machine shown in Figs. 1 to 7, above, and on page 70, includes a number of interesting design details and has the important advantage that it is equipped with two sets of rolls which can be interchanged to vary the capacity over a wide range. One set of the rolls enables the machine to be employed for the cold bending of mild-steel plates up to 16 ft. 9 in. wide by 1 in. thick, the minimum inside diameter of complete cylinder of this thickness being 3 ft. These rolls can, of course, be employed to bend plates of greater thickness, though, naturally, the width of such plates is reduced; thus, plates 1¼ in. thick could have a maximum width of 10 ft. 9 in., and those 1½ in. thick a maximum width of 7 ft. 6 in. The minimum inside diameter in the case of 1¼-in. plates is 3 ft. 6 in. The other set of rolls is for handling wider and thinner plates, the maximum width being 27 ft. with a plate ⅜ in. thick, and the minimum inside diameter being 2 ft. Examples of alternative rollings with this set of rolls are:—Plates 15 ft. 6 in. wide by ¼ in. thick, and plates 7 ft. wide by ⅛ in. thick, the minimum inside diameter in the case of the ⅛-in. plate being 3 ft. The bedplate of the machine is designed to take the longer rolls and is provided with intermediate facings so that the outer bearing can be moved along the bed towards the driving end and the roller support moved in the same direction by an appropriate amount. In the general views, Figs. 1 and 2, the long rolls are shown in position, though the short rolls are indicated by chain-dotted lines in Fig. 2. The machine has been constructed by Messrs. Joshua Bigwood and Son, Limited, Wolverhampton.

The top roll is 20½ in. in diameter and the two bottom rolls are each 16 in. in diameter. All are made from open-hearth steel forgings, containing from 0·45 per cent. to 0·50 per cent. of carbon and having a very high elongation. The top roll, which is adjustable relative to the two bottom rolls, revolves in bearings at each end and has an elongated spindle at the driving end finished with a ball, the top surface of which engages with a cup-shaped bearing carried in a vertically-adjustable yoke. This arrangement is clearly seen at the left of both Fig. 1 and Fig. 2, but plays no part in the actual bending operation. The outer end of the top roll is carried in a tilting bearing which is swung out of the way when a complete cylinder of the required diameter has been rolled so that the finished work can be drawn off from that end. During this withdrawal it is, of course, necessary to support the top roller and its weight is accordingly balanced, with the inner bearing as fulcrum, by screwing down the yoke on the ball end of the roller spindle. The top roller rotates freely, the two bottom rollers being both driven in the same direction by a common pinion meshing with the two double-helical spur wheels seen immediately below the top roller spindle in Fig. 1, the drive being through a reversing gearbox by means of a 50-h.p. motor running at 940 r.p.m. The bottom rollers are carried in fixed capped bearings at each end and are each supported at the centre by a pair of free-running rollers arranged as shown in Fig. 3.

The driving motor is not visible in Fig. 1, but its relation to the rolls is shown in Fig. 4, while its relation to the gearbox is seen in the somewhat diagrammatic view of that box shown in Fig. 5. Referring particularly to this figure, it will be seen that the motor spindle drives the first-motion shaft *a* in the gearbox, though through a flexible coupling. A pinion on the shaft *a* meshes with a spur wheel driving shaft *b*, which, moreover, carries two pinions. One of these pinions *c* drives a spur-wheel *d* running freely on the shaft *g*, and the other *e*, by means of an idler, drives the spur wheel *f*, also running freely on *g*. Between the wheels *d* and *f* is a sleeve keyed to the shaft *g* and carrying at each end the plates of a friction clutch. This clutch, which is illustrated in principle only and not in precise detail, is cone and toggle actuated and couples *d* to *g*, when moved to the left, and *f* to *g* when moved to the right. It will be clear that in the left-hand position the direction of rotation of *g* is opposite to that when in the right-hand position owing to the interposition of the idler between the pinion *e* and the wheel *f*. The shaft *g* is continued to the right and coupled to a shaft, visible below the bottom rolls in Fig. 1, which actuates the raising and lowering of the op roll, this motion necessitating reversal of shaft *g*. When the clutch is in the neutral position shown, the

shaft is not rotated and the transmission of the roll drive takes place by the wheels *d* and *f*, rotating freely on *g* and driving either wheel *h* or wheel *i*, which are free to run on shaft *j*. Between *h* and *i* is a precisely similar clutch which gives either clockwise or anti-clockwise rotation to *j*, according to its position, and, when in the neutral position stops the rotation of the bottom rolls.

The gears outside the gearbox consist of a pinion on shaft *j*, a spur wheel and pinion on shaft *k*, and a spur wheel and pinion on shaft *l*. The pinion on shaft *l*, which forms the final drive to the wheels on the spindles of the bottom roll, is not shown in Fig. 5, as the shaft passes above the gearbox, but can be seen in Fig. 4. All the gears, both in the box and outside it, have machine-cut double-helical teeth, which give smooth and silent running. The bearings in the gearbox are of the oil-ring type. The clutches in the gearbox are oil-immersed and are easily adjusted, so that they should give satisfactory service for a long period without undue wear or trouble from overload. They are operated by the two levers seen in the foreground of Fig. 1, one of which controls the raising and lowering of the top roll. The other lever controls the running and reversing of the machine. The shorter lever seen to the right actuates a clutch which enables the outer bearing of the top roll to be raised independently of the inner one, so that the roll can be tilted when it is desired to roll plates in a conical form instead of cylindrically. The large dial seen behind the pair of main levers indicates the position of the top roll and enables the operator to set it precisely so as to produce the desired degree of curvature in the plate. The handwheel near the dial is for the adjustment of the yoke at the ball-end of the top roller spindle. The gear wheels can be seen in Fig. 1, as the photograph reproduced was taken when the machine was being erected. Actually, all gears are fully protected to meet the requirements of the Factory Act. It may also be observed that the rolls seen in this figure are cylindrical, but, if preferred, they can be made slightly barrel-shaped.

The top-roll bearings may now be referred to. Two views of the tilting outer bearing are given in Figs. 6 and 7, on page 70. These views, however, show a different type of base from that employed in the machine now described. The arrangement of the bearing itself applies to Figs. 1 and 2. The roll spindle rotates in a plain bearing which is supported on what may be compared to a large eye-bolt. The bearing is not in complete contact with the eye, but only at three fixed points, with a fourth movable one at the top. The eye is hinged to the vertical screw by means of which the top roll is raised and lowered, the hinged part being moved as required by a pair of levers pivoted on the end casting of the machine and actuated by a handwheel. It will be clear that, by turning the lever seen at the top left-hand corner of Fig. 7, the bearing is freed from the eye, and can then be swung to the right out of the way, leaving a clear path along which the rolled cylinder may be removed. With plates bent to less than a full circle there is, of course, no need to use the tilting bearing. The load on the top roller is taken by the thrust ball-bearing seen in Fig. 6, and raising a lowering of the roll is done by rotation of a wormwheel of phosphor bronze, the actuating worm for which is operated by the shaft seen below the bottom rolls in Fig. 1, and driven from the gearbox. The inner bearing of the top roll has the same gear for raising and lowering, but no provision for tilting is needed. It will be observed in Figs. 2 and 3 that a pit, sloping towards the centre of the machine lengthways, is formed in the foundation. This pit receives the scale cracked off from the plate during bending, the scale being removed periodically from the centre trough. Access to the pit is gained by a boarded door in the floor at one side of the machine, partly shown in Fig. 4.

PROTECTIVE HELMETS FOR CIVILIAN WORKERS.—The Ministry of Home Security, in conjunction with the Ministry of Supply, has arranged for an extensive production of protective helmets of a new design which will be sold, at the price of 5*s*. 6*d*. each, to employers for the use of their employees. The programme contemplates an output rising to more than 500,000 helmets a week, and supplies will begin to be available at an early date. The new helmet will be known as the "civilian helmet (steel)," and, it is stated, it will afford a standard of protection as good as the present mild-steel helmets which have already been supplied to a proportion of workers in essential factories. The distribution of the helmets will be undertaken by the Ministry of Home Security, but applications for helmets will be collected by the Admiralty, Ministry of Supply, Ministry of Aircraft Production, Ministry of Health, Ministry of Transport, Mines Department, Ministry of Labour and National Service, and other Government departments, and applications should not be made direct to the Ministry of Home Security.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s*. net, or 2*s*. 3*d*. including postage.

Portable Standard of Brightness.—A simple form of gauge for checking low values of illumination is described in the specification BS/ARP No. 30, in the Air-Raid Precautions series, and this specification has now been followed by one describing a simple portable standard of brightness. This, BS/ARP No. 52, is intended to provide a rough check on the brightness of surfaces, and the nominal brightnesses specified correspond to the brightness values permitted for various A.R.P. purposes. A description and a diagram of a typical instrument complying with the requirements are given in the specification. In the case of coloured surfaces at low values of brightness, such as those which are met with in A.R.P. work, the brightness that is of importance is the "apparent brightness" of the surface and not the brightness measured on the photometric scale. Hence one of the most interesting and important features of the specification is the appendix explaining what is meant by apparent brightness and how it should be measured. [Price 6*d*. net, or 8*d*. postage included.]

Flameproof Enclosure of Electrical Apparatus.—A second revision of Specification No. 229, which deals with the flameproof enclosure of electrical apparatus for power and lighting plants, has now been published. The first edition, issued in November, 1926, comprised a general definition of the term "flameproof enclosure," a general outline of the tests to establish the quality of "flameproofness," and a suggested form of certificate to be issued by the testing authority. A first revision was published in March, 1929, which introduced only a few small changes, no attempt having been made, until that time, to provide detailed directions for the design and construction of flameproof enclosures. In the present edition, the definition of the term "flameproof enclosure" remains substantially unaltered, but the specification has been considerably enlarged to include a detailed prescription for those features of design and construction which are considered to be essential to secure mechanical strength and reliability in service. The specification at present covers apparatus for use in coal mines only and amplifies the requirements of the Mines Department Testing Memorandum No. 4. It is intended to issue, in due course, corresponding data for flameproof apparatus for use in other industries.

ANNUALS AND REFERENCE BOOKS.

Coal Trade Diary and Colliery Managers' Guide.—The 1941 edition of this useful diary and guide has recently been published. The volume, which is of foolscap size, consists of two sections, the first 214 pages constituting the information section and the remaining pages forming a diary having three days to each page. The information section contains a directory to the coalfields of the British Isles, the data given including lists of colliery owners, the names and situations of their pits, the number of workpeople employed, the class of coal mined, and the names of managers, agents and engineers. Other lists give the names and addresses of officials of trade associations and technical institutions, and of Government inspectors. The remainder of the information section is devoted mainly to the reproductions of the Coal Mines Acts, the Mining Industry Acts, the Workmen's Compensation Acts, the Factories Act, 1937, and other information of an official character. The volume is published by Messrs. F. W. Bridges, Limited, 34, Bridge-street, Hereford, whose London offices are at 37, Norfolk-street, W.C.2. The price is 8*s*. net, or 9*s*. outside Great Britain.

Diary.—Messrs. B.S.A. Cycles, Limited, Birmingham, 11, have sent us a neat leather-bound pocket diary issued by Messrs. Wm. Jessop and Sons, Limited, Brightside Works, Sheffield. It contains brief particulars of this firm's steel products and manufactures, and also many tabulated data of interest to engineers and metallurgists.

Almanacs and Calendars.—We have received monthy tear-off calendars from Messrs. Crofts (Engineers), Limited, Thornbury, Bradford; Messrs. Wadkin, Limited, Green Lane Works, Leicester; Messrs. British Pigirons, Limited, "Little Court," Pyrford Common, Woking, Surrey; and Messrs. Andamite, Limited, 52, Ebury-street, London, S.W.1.—Daily tear-off calendars have been sent to us by Messrs. Ashwell and Nesbit, Limited, Barkby-road, Leicester; and Messrs. Harrison and Sons, Limited, 44-47, St. Martin's-lane, London, W.C.2.

PERSONAL.

SIR JAMES MILNE, K.C.V.O., C.S.I., general manager of the Great Western Railway, has been unanimously re-elected chairman of the General Managers' Conference at the Railway Clearing House for the year 1941. We understand that this is the first time such an appointment has been made for the third year in succession.

MR. C. A. MORRISON, F.S.I., formerly a senior surveyor to H.M. Office of Works, has been appointed Chief Quantity Surveyor to the Ministry of Works and Buildings, on the death of MR. G. C. WIDDOWSON, O.B.E., F.S.I.

MR. GILBERT MATTHEWS has succeeded to the position of Superintendent of the Line, Traffic Department, Great Western Railway, Paddington, on the retirement of MR. F. R. POTTER. Mr. Matthews became principal assistant to Mr. Potter in January, 1939.

MR. D. W. BISHOPP has been appointed Director of the Eire Geological Survey, Dublin.

MR. C. E. SHACKLE, A.M.Inst.C.E., New Works Assistant, Chief Engineer's Office, Great Western Railway, Paddington, has retired after 40 years' service with the Company.

MESSRS. HEPWORTH AND GRANDAGE, LIMITED, St. John's Works, Bradford, have transferred their London office to Sentinel House, 46, Southampton-row, W.C.1. A depot, at which the firm's usual stocks will be held, has been opened at Worthy-place, Weston-super-Mare, Somerset.

MR. TREVOR MORGAN, M.C., K.C., J.P., at present Regional Transport Commissioner for the South-Western Region, has been appointed Regional Transport Commissioner for Wales, in succession to the late MR. A. T. JAMES, K.C. SIR ALFRED ROBINSON, K.B.E., C.B., M.Inst.T., has been appointed to succeed Mr. Trevor Morgan as Regional Transport Commissioner for the South-Western Region.

The Appointing Trustees, acting under the provisions of Section 1 of the London Passenger Transport Act, 1933, have re-appointed MR. CHARLES LATHAM to be a member of the London Passenger Transport Board for a further period of three years from January 20, on the expiration of his present appointment. Mr. Latham has been a member of the Board since 1935.

TENDERS.

WE have received from the Department of Overseas Trade, Millbank, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained at the above address, quoting the reference numbers given.

Abattoir By-Products Equipment for the Municipal Abattoir, Western Commonage, comprising blood-drying plant, bone crusher, electrically-driven rendering vessel, fat tanks, extractor, disintegrator, boiler and incinerator. Stores Department, City of Salisbury, Southern Rhodesia; March 28. (T. 15,135/41.)

Telephone Cable, lead-sheathed, comprising 25,000 yds. of enamelled and double-cotton covered cable, 31,720 yds. of underground armoured cable of various types; and 750 yds. of enamelled, silk and cotton-covered cable. South African Railways and Harbours, Johannesburg; February 10. (T. 15,139/41.)

Pole-Line Hardware, comprising overhead fittings for transmission lines. South African Railways and Harbours, Johannesburg; March 5 (T. 15,090/41.)

Electrical Distribution Material, including transformers, insulators, copper conductors, galvanised stay wire, and fuse links. Electricity Department, City of Salisbury, Southern Rhodesia; March 10. (T.Y. 15,136/41.)

UNITED STATES STEEL PRODUCTION.—During the week ending December 28, the steelworks of the United States produced steel corresponding to 97·2 per cent. of their output capacity. This figure is stated to be the highest on record.

RAILWAY-RATES TRIBUNAL.—The Court of the Railway Rates Tribunal will sit on February 18, March 18, April 22, May 20, June 17, July 15, October 14, November 18, and December 16, 1941, to hear applications regarding the granting of new, or the reduction of existing, exceptional rates, for which the consent of the Tribunal is required. It will also hear applications for new exceptional rates or for the reduction of exceptional rates. The Court will also sit on January 28, April 29, July 22, and October 21, 1941, to hear applications relating to questions of alterations in the classification of articles, of reductions from the standard charges, and of circumstances in which rebates may be allowable. Printed copies of the procedure to be followed in making applications may be obtained from the offices of the Tribunal, Bush House, Aldwych, London, W.C.2.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Addressing a Press conference at Cardiff, Mr. Harold Macmillan, Parliamentary Secretary to the Ministry of Supply, expressed confidence in the future of the Welsh coal trade. The slump that had taken place, he said, was due to the changed war situation, which could not have been anticipated. The present export difficulties were not permanent and demand for coal supplies from parts of the world which were at present closed could be confidently expected. The home market was also restricted by transport difficulties, but it must not be assumed that the whole transport system of the country was overloaded. The position was being dealt with as rapidly as possible and as it improved so would the home trade for Welsh coals. Some improvement in railway traffic has been noted of late, and it has been reported that many collieries in the Glamorgan area have been effecting clearances of wagons, which, filled with coal awaiting delivery, had stood idle in sidings for some time. Even in the Western, anthracite, area of the coalfield, which had been most effected by traffic delays, improvement has become apparent and producers have been able to complete long-standing contracts. Apart from the home trade there continued to be little activity on the Welsh steam-coal market during the past week. Foreign business was largely confined to the Portuguese and South American trades. Industrial buyers in the inland trade displayed interest in the high-volatile bituminous sorts which were difficult to secure for early delivery owing to the heavy commitments sellers had already entered into. Dry steam varieties, however, were still in slow request and plentiful. Best large maintained a good activity and the sized kinds were well sold ahead. Stems for the bituminous small descriptions were difficult to arrange for some time forward, but dry smalls were freely offering to meet a restricted demand and were consequently dull. The home demand for cokes was active but patent fuel was quiet.

The Iron and Steel Trade.—Brisk conditions were again reported in the iron and steel and allied trades of South Wales and Monmouthshire last week. There was a good demand for the various products and most producers were employed almost to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The demand for steel ingots and castings shows a steady rise. The producing works are operating at full capacity, and are turning out castings, the shapes, sizes, and weights of which would have been impracticable five years ago. Some of these products are for commercial use, notably in connection with the manufacture of steelworks and ironworks machinery, electrical plant, and agricultural-engineering plant. Producers of raw and semi-finished materials continue to make satisfactory progress; plenty of work is circulating on both war and commercial account. Producers of pig iron, hematites and steel-making alloys in various parts of the country are maintaining satisfactory deliveries to this area. Widespread activity exists in the production of all types of high-efficiency steels. Machinery and tool makers are particularly heavy buyers. Stainless and rustless steels are in strong demand, and makers of Nitralloy steels report that their outputs have increased considerably during the past six months. Metalliferous mines in South Africa, India, Canada, Australia, and New Zealand are relying on this area to an increasing extent for supplies of grinding and crushing machinery, washing plant, and dredgers and parts. Plant used for breaking up iron ore, coal, and stone is in strong request on inland account. Makers of railway rolling stock and handling more orders; British railways are buying increasing tonnage of renewal parts, including wheels, buffers, springs, tyres, and axles, but firms specialising in the production of wagons, carriages, and lorry, tramcar, and omnibus bodies, report a slight falling-off in orders. Boiler-making works are busy, and in addition there is an active call for fabricated, welded, and riveted pressure vessels, tanks, air receivers, and water-softening plant.

South Yorkshire Coal Trade.—Deliveries of all types of coal are regular. Industrial fuel is in strong demand, and consuming works continue to take heavy tonnages for stocking purposes. Railway companies are also good customers for locomotive fuel. The recent improvement in the house coal market has been more than maintained. The coke position shows little change, most varieties finding a ready sale.

THE INSTITUTE OF PETROLEUM.—The Institute of Petroleum Scholarship of 40*l.* per annum, tenable at the University of Birmingham, has been awarded to Mr. Alan Henry Baldwin, a student member of the Institution, who is at present studying in the Department of Oil Engineering and Refining.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—To ensure adequate deliveries of materials for Government work, strict adherence to the regulations under the control of distribution scheme continues, but the prospects of an expansion in the supply encourages the hope that additional tonnage will be made available for general commercial undertakings. The output of many descriptions of material is at a maximum, and the already substantial imports from the United States are likely to increase. Regular customers are anxious to place orders for ordinary industrial purposes, but find that there is little prospect of an appreciable increase in their rationed tonnage at the moment. The outlook generally, however, is decidedly better than has been the case for some time and the continued ample supply of raw materials and semi-finished products is a gratifying feature of the present situation.

Cleveland Iron Trade.—No material improvement in the supply of Cleveland pig can yet be reported. The make is still intermittent and a resumption of the regular output is unlikely so long as foundry-iron users are able to obtain adequate deliveries from other producing centres. The growing demand is covered mainly by the Midland brands coming to hand. From other quarters certain qualities of iron for particular purposes are arriving in satisfactory parcels. Merchants, however, would be glad of an opportunity to deal in a larger tonnage than is allowed to pass through their hands at present. The official quotations of Cleveland pig remain at the level of No. 3 quality at 128*s.*, delivered within the Tees-side zone.

Hematite.—The heavy make of East Coast hematite continues to pass promptly into use, mainly at producers' own consuming works, but some improvement in contract deliveries to users who are entirely dependent on the market is reported. Producers, however, have extensive commitments, and are still disinclined to discuss new business. The statistical situation is stringent, but is steadily improving as increasing quantities of American hematite arrive. Cargoes of iron from the United States are of a quality which is quite satisfactory for the needs of North of England hematite consumers. Second hands are now obtaining control of a sufficient tonnage to cover the actual requirements of their regular customers. The stabilised values of both local and American hematite are at the equivalent of No. 1 grade of iron at 138*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—The output of basic iron is slightly in excess of the heavy requirements of the producers' own steelmaking plant, but there is none of this iron on sale; the manufacturers are retaining any surplus tonnage. The nominal price of basic iron remains at 120*s.* 6*d.*

Foreign Ore.—The consumers of foreign ore are now much less dependent on imports owing to the liberal use of native ironstone. They still hold reasonable stocks of overseas ore and cargoes continue to arrive regularly.

Blast-Furnace Coke.—Durham blast-furnace coke is obtainable on the basis of good medium qualities at 35*s.* 6*d.*, f.o.r. Transactions are few, local users being well brought and sellers having little desire to increase their heavy commitments.

Manufactured Iron and Steel.—Semi-finished iron and steel supplies are fully equal to the requirements of the re-rollers. In the finished industries, all firms are turning out exceptionally heavy tonnages. The demand for steel is unabated and large imports are still necessary to supplement the production. Among the principal market quotations are: Soft steel billets, 12*l.* 5*s.* per ton; hard billets, 13*l.* 12*s.* 6*d.* per ton; joists and sections, 15*l.* 8*s.* per ton; heavy plates, 16*l.* 3*s.* per ton; and heavy rails, 14*l.* 10*s.* 6*d.* per ton.

Scrap.—Merchants are keeping the works well supplied with iron and steel scrap, but the demand has not abated, heavy grades of material being in most request. Cast iron borings are 46*s.* 3*d.*; heavy cast iron, 77*s.* 9*d.*; heavy steel, 72*s.* 3*d.*; heavy mixed scrap, 70*s.* 3*d.*; steel cuttings (in bundles), 65*s.* 3*d.*; and heavy steel trimmings, 53*s.* 3*d.*

ZINC AND ZINC ALLOYS IN INDUSTRY.—The Zinc Development Association, Lincoln House, 15, Turl-street, Oxford, has sent us illustrated leaflets dealing with the anodic oxidation, cold-rolling, colouring, and machining of zinc and zinc alloys and with zinc weatherings for the protection of exposed horizontal surfaces on building work. In all cases the subjects with which the leaflets deal consist of reprinted articles from *The Metal Industry* and other technical journals. Copies of the leaflets and other publications, may be obtained on application to the Association at the above address.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-day, 2, p.m., Storey's-gate, St. James's Park, S.W.1. Special Meeting for the presentation of the James Watt International Medal awarded to Professor Dr. A. Stodola. 2.30 p.m., General Meeting. Thomas Lowe Gray Lecture: "Progress in Marine Engineering as Influenced by the Classification of Ships," by Dr. S. F. Dorey.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, January 25. 1.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Protective Coatings on Metals," by Mr. P. A. Cartwright.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, January 25, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. Lecture: "Recent Developments in Cast Non-Ferrous Engineering Materials," by Mr. Frank Hudson.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Western Centre:* Saturday, January 25, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "An Objective Noise Meter Reading in Phons for Sustained Noises, with Special Reference to Engineering Plants," by Mr. A. J. King, Dr. R. W. Guelke, Mr. C. R. Maguire and Dr. R. A. Scott. *North-Eastern Centre:* Monday, January 27, 6.15 p.m., The Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Voltage-Operated Earth-Leakage Protection," by Mr. T. C. Gilbert.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Luton Centre:* Saturday, January 25, 2.45 p.m., The George Hotel, Luton. "Producer Gas for Road Vehicles," by Mr. Maurice Platt.

ROYAL SOCIETY OF ARTS.—Monday, January 27, 1.45 p.m., John Adam-street, Adelphi, W.C.2. Cantor Lecture II. "The Influence of Art on Instruments of War," by Mr. J. G. Mann. Wednesday, January 29, 1.45 p.m., "Municipal Manufacture of Humus from Habitation Wastes," by Lieut.-Col. F. C. Temple. Friday, January 31, 1.45 p.m., "Recent Labour Legislation in India," by Sir Frank Noyce. (Transferred from January 24.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* Wednesday, January 29, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne. "Burmeister and Wain Diesel Engines," by Mr. K. I. Overgaard. *Institution:* Friday, January 31, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Effect of Some External Factors on the Performance of Single-Screw Ships," by Mr. A. Kari.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade, during the past week, have shown little change. Boiler plates, ship plates and sections are all in great demand, and there is very little steel available for other commercial purposes. For structural sections the demand is hardening. In the black-steel sheet trade the amount of work booked is very large, and as the uses for both black and galvanised sheets have been steadily increasing, it is necessary for this output to be maintained at a maximum. Prices are steady and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the malleable-iron trade of the West of Scotland most of the works continue to be fully employed, and order books generally are satisfactorily filled. The re-rollers of steel bars are well able to cope with the current business, most of which is on Government account. The supply of semi-manufactured material is ample at present, as recent shipments of considerable tonnage have augmented the stocks previously held. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change has taken place in the Scottish pig-iron trade during the past week and the output of all the furnaces in blast is rapidly taken up. The present production, however, is not sufficient for the requirements of local consumers, and consignments have to be brought in from other districts. Fairly good stocks of raw materials are held. The market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

THREE-ROLL PLATE-BENDING MACHINE.

MESSRS. JOSHUA BIGWOOD AND SON, LIMITED, WOLVERHAMPTON.

(*For Description, see page* 67.)

Fig.2.

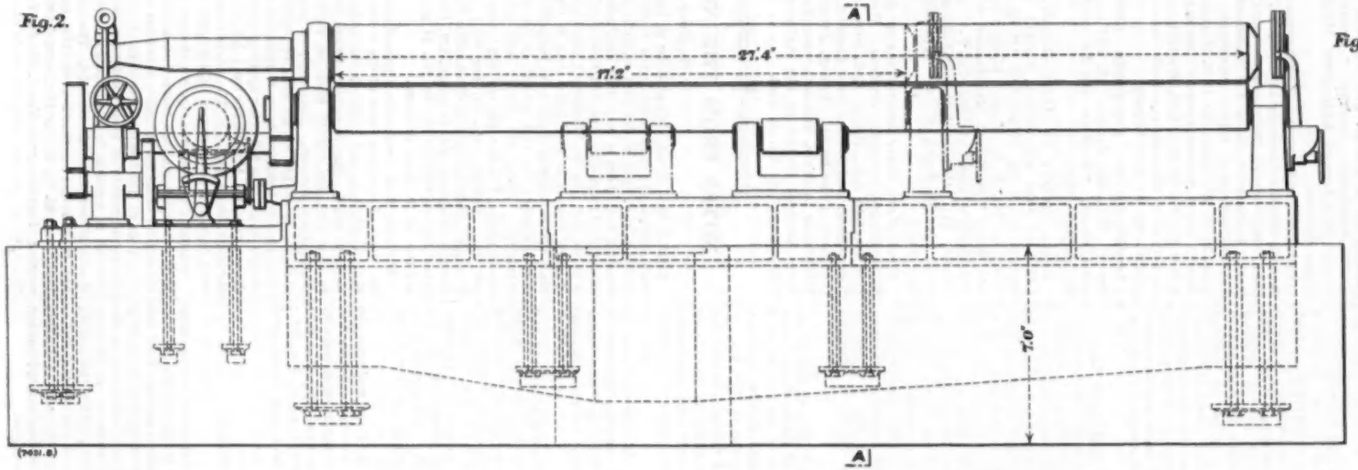


Fig.3. SECTION AA

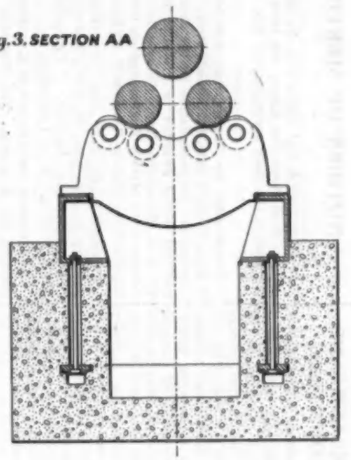


Fig.4.

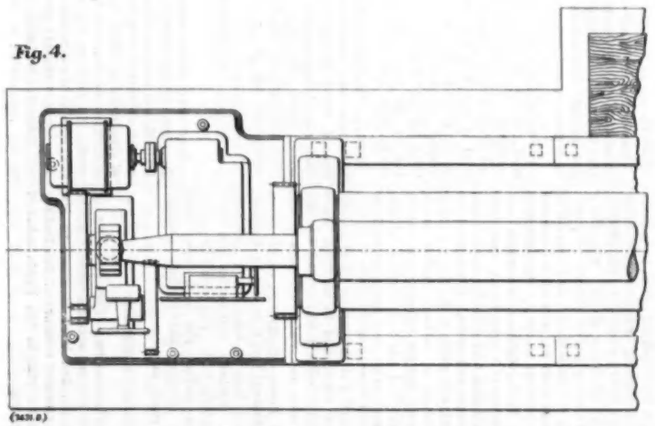


Fig.5.

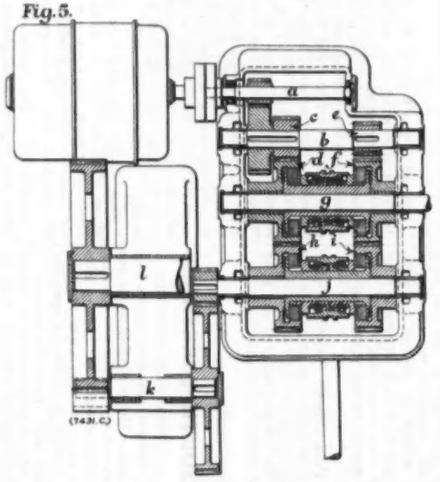


Fig.6.

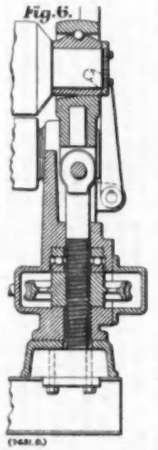
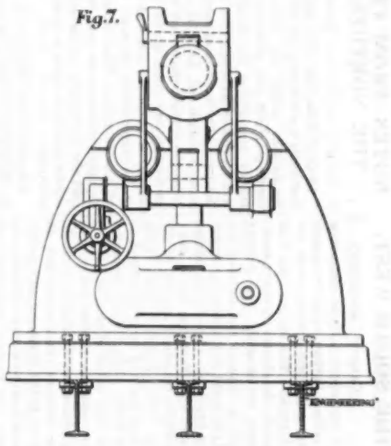


Fig.7.



STEEL INDUSTRY OF THE UNITED STATES.—During the first eleven months of 1940 the total production of steel ingots in the United States was 58,946,185 net tons, as compared with 45,762,972 tons in the corresponding period of 1939.

"CHEAP STEAM."—The January, 1941, issue of *Cheap Steam*, we note with interest, is the first part of the 25th volume of this bi-monthly publication. To introduce a new journal in the midst of a major war is an undertaking calling for a robust faith, which, in this case, has been justified by the result. Originally the house journal of Messrs. Bennis Combustion, Limited (then Edward Bennis and Company), *Cheap Steam* has subsequently widened its scope while retaining the study of boiler-house practice as its chief interest, and is now conducted as a separate concern by Messrs. Cheap Steam, Limited, 28, Victoria-street, London, S.W.1. We trust that our contemporary may weather the difficulties of the present war as successfully as those of 1916.

"SCIENTIFIC FACTS AND DATA."—This is the title of a small book recently issued by Messrs. Negretti and Zambra, 38, Holborn-viaduct, London, E.C.1, and containing numerous facts and figures, mostly relating to meteorological matters. The entries, which are arranged in alphabetical order, include several items of information which may help the engineer to increase his store of general knowledge. He can find, for instance, the temperature of a whale, and he can also find the firm's address if he thinks to look for it under their name among the alphabetically arranged entries; it appears nowhere else. The arrangement of these might, perhaps, be improved in places, but among them there is much useful and interesting material, so that the book is well worth keeping at hand for reference.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, JANUARY 24, 1941.

VOL. 151. No. 3915.

DISTRICT HEATING.

NEITHER in Sir Thomas More's *Utopia* nor, so far as we can recall, in Samuel Butler's *Erewhon*, was there any mention of the methods of domestic heating employed in those ideal states; a curious omission, since both authors were English to the core, and well schooled not only in the vagaries of the English climate, but also in the literature of those classic times when central heating by hypocaust was a widespread amenity and the cult of the bath was, perhaps, more generally diffused than in either of their own periods. Both, too, were widely travelled and must have noted the importance attached to the maintenance of bodily warmth in countries colder than their own, and the methods adopted to ensure it. Sir Thomas More was enough of a scientist in mind, if not in experience, to predict the use of the incubator for hatching eggs; and Butler, who lived into the present century, saw the uses of steam expand many-fold, and must have deplored the pall of smoke with which every big city advertised the deficiency of the open coal fire. There was some excuse for More, perhaps; even 130 years after his death, Pepys regarded a wash with warm water (at the behest of his wife, "because she do use it herself") as sufficient matter for a special entry in his *Diary*. Butler, however, seems to have shared the short-sightedness of his contemporaries (some of whom should have known better), who travelled for half a century behind steam locomotives before realising that the steam could warm a whole train much more effectively than a gallon of hot water or a mixture of chemicals in an iron canister did the feet of those travellers who could afford the modest luxury of a footwarmer.

During the past 20 years, the erection of many large office blocks, flats, public buildings and such semi-public institutions as schools and hospitals has accustomed the public in general to central heating, but its use has not yet become widespread in individual homes. Frequently there is a definite feeling against it, based on objectionable features of the installations in the office or works where the householder spends his working hours. Actually, the average home probably offers a more favourable environment for a central heating installation than does a larger building, so far as concerns its adjustability to the requirements or whims of the individual, provided always that it can be assured of that modicum of attention that any thermal plant must have if it is to give optimum service. That, however, is rather beside the present point, which is that central heating, more especially by hot-water circulation, is still regarded in this country as a luxury in a private house; a state of mind which the present principles of local rating do nothing to eradicate. This being so, it is not surprising that so little interest should have been taken in district heating, when so large a proportion of those who would have to decide for or against its adoption, in any given instance, have little or no experience in their own homes which might serve as a guide.

Just how backward this country is, however, in adopting district heating in connection with the many housing schemes carried out in recent years, we had not fully realised before studying the paper which Mr. D. V. H. Smith presented in Glasgow on January 14 before the Institution of Engineers and Shipbuilders in Scotland, on "District Heating and its Relation to Housing and Town Planning." By comparison with the installations which he cited in France and Germany, the few examples existing in this country, in Manchester and Dundee, are relatively insignificant; yet the opportunities for applying the principle on a scale likely to ensure the most economically satisfactory results are probably as numerous as in any country in Europe. It is true that, as Mr. Smith pointed out, there are many systems of central heating in the British Isles which are so large in capacity that they might well rank as district-heating installations, considered merely from the technical standpoint; but they were not designed as such, and are not commercial projects. The basic idea in district heating, however, is to provide a constant supply of heat to the district served, at a cost contrasting favourably with the methods of heating generally in use, while providing a satisfactory return for the initial outlay and maintenance costs. It is interesting to examine some of the figures adduced by Mr. Smith, and to see how far this ideal has been realised in practice.

Broadly speaking, Mr. Smith observed, artificial heat is essential in the British Isles during from five to seven months in each year; and the average coal consumption required by an ordinary household in a city such as Glasgow is about 4 or 4½ tons annually. In many of the district installations on the Continent, however, comparable in extent with the larger modern housing estates in Glasgow, all the heat required is supplied for a fuel consumption of about 1½ tons per household per annum. No attempt was made to institute comparisons with United States and Canadian practice; for, although district heating has been established there for at least 60 years, the greater temperature range to be overcome affects the force of any arguments that might be based on such a comparison.

The annual consumption of coal in Great Britain for domestic fuel and for warming factories is of the order of 78,000,000 tons. In this total, no allowance is made for the coal equivalent of electric current and gas employed for space heating, but, even so, this total represents more than half of the aggregate annual consumption for industrial and domestic purposes. A fair average thermal efficiency for electric generating stations is about 30 per cent. and for industrial heating plants, probably about 50 per cent., whereas that of the domestic open fire averages no more than about 15 per cent., showing that there is a considerable field for possible economy. The city of Glasgow, according to the paper, consumes over a million tons of coal a year for domestic purposes alone, or nearly 3,000 tons a day; but, on the basis of 15 per cent. average thermal efficiency, only about 450 tons a day is usefully employed. Taking a similar proportion throughout the British Isles, the annual wastage appears to be not less than 30,000,000 tons.

Turning to Continental practice, Mr. Smith mentioned the Cité Jardins du Plessis Robinson, in the Seine department, where 2,400 houses and flats of various types are warmed from two central boiler houses, each containing four Economic-type

boilers, fired with oil. Normally, three boilers in each plant are in use and one in reserve. The capacity of each plant is 18,000,000 B.Th.U. per hour, and the hot water is circulated through the system by electrically-driven pumps. The coal consumption is about 1½ metric tons per flat per annum. At the Cité Jardins de Suresnes, in the same department, 2,500 flats are warmed by a series of central-heating systems comprising, in all, 80 cast-iron sectional boilers, distributed in 24 heating chambers, maintained by a staff of five whole-time and 16 part-time attendants, provided under contract by the construction of the system.

In the Steiglitz district, in Berlin, the district heating plant supplies over 140 blocks of buildings, including more than 4,000 houses or flats, and the total normal load is 120,000,000 B.Th.U. per hour. The total length of the hot-water mains, exclusive of circuits within the buildings, is about 13 miles, and the most distant block is over a mile and a quarter from the central station. The heating and hot-water services are supplied on a three-pipe system, a 20-in. main supplying the heating circuits at an average temperature of 160 deg. F. (maximum, 190 deg. F.), and a 10-in. main delivering hot water at an average of 180 deg. F. (minimum, 170 deg. F.). The third main forms a common return. Process steam is supplied in addition, for industrial purposes. It is stated that the temperature drop at the extreme point of the mains does not exceed 4 deg. F. The boilers also supply steam to two turbo-generators, with a total capacity of 6,000 kW, operating with a back pressure of 5 lb. to 10 lb. per square inch. The overall efficiency of the plant is high (60 per cent. in summer and 70 per cent. in winter, as a result of the favourable load factor.

Three installations in Great Britain were described in the paper—two in Dundee and one in Manchester, the latter being supplied from the power station in Dickinson-street. For various reasons, however, this is not representative of modern practice and is of less value as an argument in favour of district heating than those at Dundee, comprising 250 houses and 268 houses, respectively. The former, at Logie, has been in operation since 1920, and the latter, Hospital and Stirling Parks, since 1922. At Logie the heating and hot-water systems employ gravity circulation. At Hospital and Stirling Parks, the system uses accelerated hot water, circulated through two separate circuits of flow and return mains. The total capital cost of the plant, including the boiler-house, for the two schemes was 59,000*l.*, or an average of 114*l.* a house; against which there was to be set a saving of some 40,000*l.*, due to the omission of flues and fireplaces. The net outlay, therefore, was only 37*l.* a house. In 20 years, the operating costs at Logie have been 51,954*l.*, and the receipts, about 45,000*l.*; and at Hospital and Stirling Parks, in 18 years, 42,106*l.* and 43,569*l.*, respectively. These figures include certain capital charges and an allowance for depreciation. The all-in cost of operation is rather less than 3*s.* 2*d.*, and the charge to the tenants has been slightly over 4*s.* 3*d.*, per week per house.

The considerable reconstruction that will be necessary after the war will afford excellent opportunities for the introduction of district heating in many industrial and residential districts in this country, and it is to be hoped that due note will be taken of these possibilities by the newly-formed Ministry of Works and Buildings. Its application to the area in the City of London, now being cleared after the fire-bomb attack of December 29, is one of the most obvious of these opportunities, and one which should enable a useful diminution to be made in the volume of traffic congesting that area in normal times, if the supply could be effected from a station on the river bank, to which fuel could be delivered by water. In extending the system to individually-owned property, however, it would be essential to provide certain safeguards against interruption of the service; and it would be desirable, too, that some change should be introduced in present methods of rating, which have done more than is sometimes realised to prevent the wider adoption of improvements that technical advances have made possible. The evidence adduced by Mr. Smith shows clearly that schemes of this kind offer definite economic advantages.

THE GOVERNMENT AND THE USE OF ELECTRICITY.

NAPOLEON'S dictum that in war the ratio of the moral and material is as three to one is probably no less true in 1941 than when it was first pronounced. Mechanisation, it may be admitted, has given the armed forces of both sides a greater striking power; and has enabled the range of the blows delivered to be extended in a way which would have surprised and pleased the victor of Lodi. At the same time, the heroic struggles of the Finns and the Greeks, and our own retreat from Dunkirk in the face of overwhelming forces, have shown that the moral factor, even now, is extremely important, and that its value is increased by the provision of proper equipment in sufficient quantities.

The lesson to be learnt from this is clear; and the results might well be applied not only on the military, but also on the industrial front. Matters must, in fact, be so organised that everything is done to take advantage of methods which peace-time has shown to be useful. At the same time, new means must be sought so that efficiency shall be increased as widely as possible. This is particularly true in the field of power utilisation. Since 1918, research, design and every-day attention to detail have greatly improved the efficiency of the processes whereby the sun's energy is employed indirectly for our use and convenience. The coal consumption required to generate a kilowatt-hour of electricity has been reduced to a figure which would have seemed almost fantastic 20 years ago. The same is true, *pari passu*, in the gas industry and in many other branches of engineering, notably that concerned with the internal-combustion engine. Much use is being made of these advances by all the armed forces, and it may be presumed that investigations now in progress will lead to still further improvement. That these investigations are being carried out regardless of cost, as is the way in time of war, may be deplorable financially, but the results will be available generally when peace is declared; and to that extent history will repeat itself by showing that extravagance sometimes has its redeeming features.

At the same time, it cannot be said that progress in the pursuit of new methods is equally satisfactory in every field, nor, what is perhaps even more important, that full use is being always made of the means already at our disposal. We may illustrate this by referring to two matters which, though not of fundamental importance in themselves, are thought by some to show a certain bureaucratic indolence and lack of imagination which at the present time may well be indicted. The first of these deals with the attitude of the War Office and Ministry of Works and Buildings towards the use of electricity and gas for any other purpose than lighting, in the new buildings that are now being erected for various purposes all over the country. Representations on this matter were made to the Joint Committee of Electricity Supply Associations some twelve months ago, and the conclusion was reached that there was evidence that this attitude did exist. According to the current issue of the *I.M.E.A. Journal*, the attention of the Electricity Commissioners was drawn to the matter and appropriate action was promised. The only result, however, seems to have been the production of a Corps Routine Order which, in effect, prohibits the use of electricity or gas for any other purpose than lighting, on the grounds that both are too expensive. There are also reasons for believing that the Order goes farther and prevents any inquiry being made as to the relative costs of alternative methods of heating and cooking. In commenting on this state of affairs, the *I.M.E.A. Journal* says: "It is a pity that certain Government departments are evidently prejudiced against the use of electricity for purposes other than lighting, on the score that the cost is high, and it is time these departments or the persons responsible for the specifications were fully informed as to the relative methods of gas and electricity for all purposes. Where Government departments are dealing with public funds, the electricity and gas industries should at least be given an opportunity to compete with other forms of heating, and not be excluded from specifications on the assumption that they are too expensive." With that statement of the position there will be general agreement. Both the electrical and gas industries naturally think that the commodity in which they deal possesses certain advantages over that of their rivals. This view is probably supported by those who are concerned with solid fuel. In these times, however, all interests, except apparently those represented by certain Government Departments, will agree that there should be a fair field and no favour and that each case should be decided on its merits. The position is the less tenable in view of the fact that the Mines Department has recommended economy in the consumption of solid fuel, the difficulties in connection with the transport of which have recently been brought unpleasantly to the notice of the public. Nobody wishes that gas or electricity should be used when other methods are, on examination, found to be more desirable. This is no time, however, for reliance on a purely economic argument, especially when other factors, particularly that of convenience, ought to be taken into account. Both the departments which have been criticised have recently acquired new political chiefs, and it is to be hoped that they will not delay in bringing about a change for the better. They might do worse, in fact, than follow the example of Mr. Morrison who, when Minister of Supply, amended the specifications for the electrification of Government buildings so as to bring their requirements more into line with war-time conditions, thus reducing the cost and avoiding the delay that was occurring in their completion.

Another field in which similar action is desirable is that concerned with road traction. As is often observed, this is a mechanised war, which is another way of saying that it is an oil war. For its conduct, very large quantities of liquid fuel are required, most of which has to be imported. Quite rightly, restrictions have been placed on the use of this fuel for unofficial purposes, though it might be argued, at least as far as some private road vehicles are concerned, that they are not yet as drastic as they might be. There are thus good reasons why a search for suitable substitutes should be made, and among those suggested is the greater use of electrically-propelled vehicles for short-run delivery and other purposes. To prove the strength of the case it may be mentioned that there are some 100,000 local-delivery vehicles in this country which, assuming a daily run of only 40 miles, consume something like 70,000,000 gallons of petrol per annum. If this amount could be saved it would materially relieve the shipping situation, or the fuel could be employed for more important purposes.

There was a time when the Government appeared to recognise this, for, as recently pointed out in *The Electrician*, instructions were given that every consideration in the matter of supplies should be given to the manufacturers of electric vehicles. The result of this encouragement was that the output rose from about 1,000 per annum at the beginning of the war to between 2,000 and 3,000 last March, and additional manufacturing facilities were being provided to increase the figure to 7,000. For some reason, however, all the relevant Orders were cancelled later in the year, so that, at the present time, the manufacture of electric vehicles is at a standstill. Once again, lack of imagination seems to be the principal reason, combined with the failure of Government Departments to co-operate. For instance, the necessary steel for manufacturing the vehicles can only be obtained with the approval of the Minister of Transport, while, before an electric vehicle can be purchased, the potential user must obtain a licence from the same authority. By these actions, the import of fuel is being encouraged though at the same time the Board of Trade is restricting the shipping space available for equally essential goods, especially foodstuffs. This is a matter which should receive attention from some co-ordinating authority, perhaps one of the new Committees. In present circumstances, when such stress is being laid on economic questions, there can be no excuse for a refusal to investigate alternative methods, properly supported by experience, even though the claims for them may be submitted by obviously interested parties.

NOTES.

STEEL DISTRIBUTION SCHEME.

AN important step was taken in the last quarter of 1940 to put on a uniform basis the procedure under which Government Departments authorise the purchase of steel. A standard form, known as Form M, has been prepared and it is on this that all Government Departments are now issuing their authorisations to acquire steel. The form gives the necessary authority to a contractor to order steel by quoting the symbol of the Department concerned, the Departmental authorisation number, and the period for which the quantity of steel authorised may be ordered. The steel may only be ordered for the purposes stated on the form, or to replace steel which has been used for these purposes. Moreover, in placing the order with makers of steel products, the contractor must state that it is "authorised on Form M. The authorisation given to a contractor enables him either to buy directly from the makers of steel products, up to the tonnage specified, or to issue sub-authorisations—also on Form M—to sub-contractors for any part of the tonnage authorised. Contractors requiring to issue sub-authorisations can obtain the necessary copies of Form M from the Government Department, or contractor acting for a Government Department, from whom they received their own authorisation. It is stated that the procedure outlined above covers 90 per cent. of the steel requirements of this country, and its general purpose is to ensure that firms only acquire steel for purposes approved by Government Departments. In the case of equipment required by factories which may be engaged on work for several Government Departments, or on civil work, it may not be possible to obtain an authorisation from a single Department as the work involved is not entirely its own responsibility. In this case, permission to acquire the steel involved is obtained by a licence from the Iron and Steel Control, Steel House, Tothill-street, London, S.W.1, to which application should be made in all instances in which the steel is not covered by an authorisation on Form M. The only other exception to the use of Form M is in the case of certain authorisations issued by Government Departments prior to October last, but, provided that the particulars as to Department are properly set out, steel can be ordered under these pre-October authorisations for the time being. Recently, a further arrangement has been made whereby alloy and carbon steel are allocated separately and a special form, Ma, is used to authorise the purchase of alloy steel. Until this new form can be printed and brought into use, however, Government Departments will stamp "alloy steel" on the existing Form M, when the purchase of alloy steel is authorised. When, on the other hand, the purchase of alloy steel is not covered, the form will be stamped "This form does not authorise the purchase of alloy steel."

DEMOLITION OF WATT ENGINES.

Consistent support has always been given in these columns to efforts towards the preservation of relics of early engineering, and it is with some regret that we learn from the Ministry of Supply that two early beam engines are now to be broken up for scrap. These engines are being removed from the Deptford Waterworks. One of them was supplied by Messrs. Boulton and Watt in 1812, the other dating from 1824. A fairly full illustrated account of the engines is given in ENGINEERING, vol. 133, page 617 (1932). At the time the account was written, the engines had been out of service for about seven years, after working regularly for over a century. It may be conceded that the Metropolitan Water Board, to whom the engines belong, is acting for the best in the national interest at the present time, since the engines represent a considerable amount of cast iron. Moreover, the Board have always shown a commendable respect for the work of the early engineers; for instance, the links of the parallel motion of the engines in question were removed some time ago and preserved by being used as lamp standards in the engine house of the Kempton Park pumping station. It may be mentioned that the cylinders, pumps, air vessels, and some other parts of the Deptford engines are not those originally fitted, considerable rebuilding having taken place in 1843, when the plant was remodelled by John Rennie to meet an increased demand. The beams, flywheels, cranks, and some other parts, on the other hand, have all the appearance of being original, the cast-iron connecting rods, for example, being identical with those shown on a drawing in the Boulton and Watt collection at Birmingham, and dated 1800. It is not to be expected that parts of any considerable weight and bulk can be held back from the cupola, but it may be suggested that the authorities at the South Kensington Science Museum might find some relics which it may be worth adding to the collection there. Incidentally, the Ministry of Supply should know better than to describe Watt as "the inventor of steam power."

MACHINERY INSPECTION IN WESTERN AUSTRALIA.

The annual report for 1939 of the Inspection of Machinery Branch, Mines Department, Western Australia, presented by Mr. Richard C. Wilson, chief inspector of machinery, to the Under-Secretary for Mines, shows that there was an increase in the number of inspections carried out, by comparison with the previous year. The total number of registered boilers and unfired pressure vessels increased from 4,401 to 4,572, after allowing for the removal from the register of 22 boilers, 16 of which were permanently condemned. There were 86 fewer repair notices issued than in 1938. Of the 193 new boilers registered, 16 were imported from the United Kingdom. Most of the steam boilers built in the State were small units for the dairy industry. From time to time, the report observes, old Cornish and Lancashire boilers have been converted for use as air receivers, the usual practice being to remove the flue tubes to increase the capacity. This involved removing and replacing one end plate, blanking the flue openings by riveted cover plates, and fitting longitudinal stays to support the cover plates and the portions of the end plates not stayed by the original gussets. During the period covered by the report, three Cornish boilers were converted into receivers, but without removing the flue tube. Blanks were fitted inside the flue tube near each end and secured by fillet-welding. Gusset stays were fitted to support these blanks and were similarly attached to the plates and the flue tube. To allow access to the flue tube for welding, and to facilitate cleaning in service, openings were cut in the top and bottom of the tube. This mode of conversion was found to be much cheaper than the old method, and gave practically the same receiver capacity. Among the "explosions and interesting defects" recorded in Section II of the report, mention may be made of the failure of a cast-iron calorifier, lined with stainless-steel plate about $\frac{1}{8}$ in. thick. The lining plate was flanged at each end over the flange of the cast-iron shell, and cast-iron covers were bolted to each end. After about 12 months' use, the stainless-steel lining was found to be corroded through in several places at the heel of the top flange, suggesting that stainless steel is not proof against stress corrosion.

REGISTRATION FOR WAR WORK.

Speaking in the House of Commons on Tuesday, January 21, Mr. Ernest Bevin (Minister of Labour and National Service) made an important pronouncement regarding the Government's intentions for the development of war industry. So far as reserves of industrial man-power were concerned, Mr. Bevin stated, "the reservoir was practically dry" and it would be necessary to enrol women in greatly increased numbers. In the first place, however, the Government would apply the powers conferred by the Persons and Property Act of May, 1940, to make a survey of those available for employment on national production and would then introduce industrial registration by age groups, preparatory to imposing compulsion in the engagement and retention of employees in industries scheduled as of national importance. In these industries, employers would no longer have the right to dismiss employees, except on grounds of misconduct, nor would employees be at liberty to change their jobs. There would be a right of appeal on both sides. Steps would be taken to eliminate short-time working and, if necessary, a minimum number of working hours would be prescribed. Further suspensions of trade-union privileges might be required, but due safeguards would be provided for their restoration after the war. To meet the demands of the Services, there would be a further revision of the Schedule of Reserved Occupations, and it was expected that, before long, arrangements would have to be made to call up men of 19, as well as those over 36. The application of the principle of industrial conscription would be extended to managerial and supervisory staffs. The Government proposed to make arrangements for the reinstatement in their former employment of persons who were directed to transfer to work of national production, on the lines of the arrangements already in force with respect to men called up for the Forces.

WAGES IN SHIPBUILDING AND ENGINEERING.

In our "Labour Notes," on page 57, *ante*, it was recorded that the National Arbitration Tribunal had completed its hearing of the claims put forward by the Amalgamated Engineering Union and the National Union of Foundry Workers for increases in wages and the restoration of certain working conditions existing before June, 1931. The Confederation of Engineering and Shipbuilding Unions also sought an increase of 10*s.* a week, with an equivalent advance in piece-work rates. The findings of the Tribunal have now been published. In both industries, an increase is awarded of 3*s.* 6*d.* a week in the war bonus to be paid to all adult male employees, to be applied in the same manner as the existing national bonus. The award is to take effect as from the beginning of the first full pay period after January 20. The Tribunal rejected the claim of the Amalgamated Engineering Union for the restoration of the pre-1931 conditions. It is stated that the decision will affect more than 1,000,000 employees in the engineering industry, and about 200,000 engaged in shipbuilding, ship-repairing and associated trades.

AIR AND ROAD CASUALTIES.

During the month of December, 3,793 civilians were killed in air raids on the United Kingdom, while during the same period there were 1,313 deaths as a result of road accidents. In other words, various native agencies have had about a third the success of the enemy in inflicting fatal loss upon the inhabitants of this country. This state of affairs is one which invites both reflection and corrective action. While the number killed in air raids has decreased considerably from 6,954 in September, when the intensive air attacks began, to the figure just quoted, the deaths from motor accidents rose by 157 over the figures for December, 1939. It may be pointed out, also, that while the official reaction to the air raid fatalities was immediate, and the more vigorous policy with regard to protection which followed has had at least some success, the attitude towards road deaths has been mainly negative, even if we except the Minister of Transport's statement that it is "a shaming record." The facts of the position and possible remedial steps are set out in the same statement, which points out that, though lighting restrictions may be given as an explanation, they are no excuse for such continued carelessness on the roads—carelessness for which all classes of users must share the responsibility. As the Minister tells pedestrians, very few life-preserving patches of white are worn at night. On the other hand, the figures show that the deaths during daylight have almost doubled, a fact which seems to indicate that the vehicle driver is frequently to blame. A detail which is not mentioned in the summary issued by the Ministry of Transport is what proportion of casualties is attributable to Service vehicles, some types of which appear to be less easily controlled than the general run of civilian vehicles.

OBITUARY.

VISCOUNT WAKEFIELD OF HYTHE, G.C.V.O.

VISCOUNT WAKEFIELD OF HYTHE, whose death, we regret to record, occurred at Beaconsfield on Wednesday, January 15, in his eighty-second year, was well known as an enthusiastic advocate and benefactor of aviation. He financed a number of long-distance flights which, though they undoubtedly also had a publicity value, were of importance in that they enabled many useful lessons regarding design and performance to be learned and thus advanced our knowledge of aeronautical science.

Charles Cheers Wakefield was born in Liverpool on December 12, 1859, and, after being educated at Liverpool Institute, entered the office of an oil broker. In 1891 he came to London, where he was associated with an American oil corporation, and, eight years later, he set up in business for himself and founded the firm of C. C. Wakefield and Company, Limited, which now has a world-wide reputation as producers of lubricating oil and associated appliances. His other business interests included the directorships of a number of companies, especially those connected with insurance, while he played a large part in the civic life of the City of London, being elected to the Court of Common Council in 1904 and serving as Sheriff in 1907 and 1908. He was elected an Alderman in 1909 and served as Lord Mayor in 1915-16. During the time he held this high civic office he took a great personal interest in the stimulation of recruiting and in other ways played a worthy part during a most difficult time. Wakefield's philanthropic interests were also manifold. He was the benefactor of numerous hospitals and a prominent Freemason. In his desire to promote a mutual interest between the various parts of the Empire he actively supported the Imperial Cadet movement and organised visits of teams of young marksmen from overseas. His attitude to youth was further shown by his authorship of a small volume, *On Leaving School and the Choice of a Career*, which contains a number of useful hints for those about to start on their life's work.

Valuable as all these endeavours were, however, Wakefield's activities would hardly call for recognition in ENGINEERING were it not for the part he took in the development of aviation. His services in this respect were probably those which will be most permanently valuable to the community and the Empire. As long ago as 1910 he addressed a public meeting in the City on the urgent Imperial aspects of aviation and appealed for public support and enthusiasm. After the 1914-18 war he supported the flights of Sir Alan Cobham to Australia and back and round Africa, and helped Miss Amy Johnson to make her famous flight to Australia. As vice-president of the Institution of Aeronautical Engineers, now incorporated with the Royal Aeronautical Society, he presented an annual gold medal for award to the designer of the best invention tending towards safety in flight. He financed Sir Henry Segrave's motor-car speed trials at Daytona and Miami and gave a gold trophy for speed and presented the Golden Arrow motor car and the Miss England speed boat to the nation. His practical support of aviation was not confined to England, as he presented light aeroplanes to the Toronto Flying Club, to Major-General O'Brien, for his use as President of the Aviation League of Canada, to the people of Australia in commemoration of Hinkler's flight, and to the Dominion of New Zealand. For some years he also provided a series of Wakefield scholarships for the benefit of students at the Air Force Cadet Training College at Cranleigh. In 1929 he took the opportunity provided by Sir Alan Cobham's air tour of Great Britain to investigate the question of municipal landing grounds in order to ventilate the subject. As a result, a Conference on Municipal Airports was called under the auspices of the Royal Aeronautical Society, the Royal Aero Club, and the Air League.

Wakefield received a knighthood during his tenure of the office of Sheriff, and was created a baronet in 1917, while he was Lord Mayor. He was appointed a Commander of the Order of the British Empire in 1919 and raised to the peerage as Viscount Wakefield of Hythe in 1934. Two years later he was created Knight Grand Cross of the Royal Victorian Order. He was the holder of a number of French, Belgian, and other foreign decorations, and was an honorary LL.D. of Colgate University. He was an Honorary Fellow both of King's College, London, and of the Royal Aeronautical Society and a Vice-President of the Royal Aero Club. He was elected an Honorary Freeman of the City of London in 1935.

PROFESSOR B. P. HAIGH, M.B.E.

A RESEARCH worker of exceptional qualifications, and an outstanding lecturer, has been lost to the engineering profession by the death, on January 19, of Professor B. P. Haigh, of the Royal Naval College, Greenwich. Professor Haigh, who was 56 years of age, and had been in poor health for some years, had been seriously ill for only a short period with a chill which developed into pneumonia.

Bernard Parker Haigh was born in Edinburgh on July 8, 1884, and was a scholar at Allen Glen's School, Glasgow, from 1896 to 1901. In the latter year, he was awarded an Allen Glen University Exhibition and proceeded to Glasgow University for three years, obtaining a number of other bursaries and scholarships by the consistently high quality of his work, and graduating B.Sc., in 1904, with distinctions in electrical and mechanical engineering, and experimental physics. During his university course he spent summer vacations in the works of Messrs. John Broadfoot and Company, Whiteinch, and Messrs. Mirrlees, Watson and Company, Glasgow; and, after taking his degree, was apprenticed for five years to Messrs. Bruce Peebles and Company, Edinburgh. The last two years of this apprenticeship were spent as personal assistant to Mr. J. L. la Cour, the then chief engineer of the company, in designing, installing and testing the equipment of electrical substations. Mr. la Cour had also a private practice as consultant, and Haigh, on the conclusion of his apprenticeship, spent much time in Germany during 1908-9, as his assistant there.

In 1909, he returned to Edinburgh as leading draughtsman with Messrs. Brown Brothers, Limited, where he spent two years on the design of steam and hydraulic steering gear and the development of electrical steering gear, and took out several patents in connection with this machinery. While still with Messrs. Brown Brothers, he had been associated as assistant with the late Professor Archibald Barr, at Glasgow University, chiefly on electrical and hydraulic work, and eventually this became a whole-time appointment, which continued until 1913. In that year, he was appointed lecturer and assistant professor, under Sir James B. Henderson, then Professor of Applied Mechanics at the Royal Naval College, and eventually succeeded him on Sir James Henderson's retirement in 1921. Of the details of his work at the College little can be said in present circumstances, but his reputation for research on fatigue in metals has been long established and it is no secret that much of his work in this field originated in marine engineering problems directly arising from the great increases in power and speed of warships during his tenure of the professorship. It was for a thesis on this subject that the University of Glasgow, in 1915, conferred upon him the degree of Doctor of Science. In addition to his steering-gear patents, previously mentioned, he had patented various improvements in single-phase traction motors for railway purposes, but his name was best known in connection with the Haigh electromagnetic fatigue-testing machine, a description of which appeared in our 138th volume. As the record of his career indicates, however, Professor Haigh was no narrow specialist, but a competent engineer who could bring a varied practical experience to bear upon novel problems. During the last war, he acted as chief adviser to the Paravane Department of the Admiralty, in which he was directly responsible to Commander Sir C. D. Burney, C.M.G., the inventor of that device; and, in subsequent years, he served on a number of special committees of the Admiralty and the Royal Air Force, as well as upon various panels of the British Standards Institution. Professor Haigh was a member of the Institution of Civil Engineers to which he was elected as an associate-member in 1911 and transferred to the class of member in 1922; and of the Institution of Mechanical Engineers since 1931. He was also an associate of the Institution of Naval Architects, and had served on the Council since 1938. He was the author of numerous papers, among which may be mentioned two dealing with the use of electric welding in ship construction, the second of which, delivered in 1934, was awarded the Institution Premium. As a speaker, he possessed an arresting style and a remarkable ability in the simple presentation of complex subjects.

COLONEL C. H. KUHNE, D.S.O., O.B.E.

BY the death of Colonel C. H. Kuhne, of the Royal Army Ordnance Corps, as the result of a motor accident while on duty, the mechanical-engineering branch of the Army has lost an officer whose record augured unusually well for his future prospects, and one who had to his credit a considerable share in the efficiency that its mechanical transport has demonstrated so notably in recent operations in the Western Desert. He was only 49 years of age, but had acquired, during his professional career, a breadth of experience and a degree of responsibility beyond the average.

Carl Hans Kuhne was of Danish descent, though of English birth, being a native of Plymouth, where he was born on June 24, 1891. His general education was received at May Place School, Malvern Wells, between 1899 and 1905, and at Plymouth College from the latter year until 1908, when he became an indentured apprentice in the marine-engine works of Messrs. R. and W. Hawthorn, Leslie and Company, Newcastle-on-Tyne. There he remained until 1912, passing through the fitting, erecting and machine shops, and concurrently attending evening classes at Rutherford College. On the completion of his apprenticeship, Kuhne made a round voyage to Australia as junior engineer in the Shire Line steamer Argyllshire, but, in 1913, rejoined Messrs. Hawthorn, Leslie and Company as a learner assistant to their outside manager, on the fitting of machinery in warships then under construction at H.M. Dockyard, Devonport. Shortly after the outbreak of war in 1914, however, he relinquished this appointment to enter the Royal Army Service Corps, in which he was gazetted 2nd Lieut. in October of that year. Promotion came rapidly, and by April, 1915, he was in France with the temporary rank of Captain and the command of the mechanical transport of the 18th Brigade, Royal Garrison Artillery. Four months later he was made a major, being by then in command of the whole of the mechanical transport of the heavy artillery attached to the Fifth Corps, amounting to nearly 1,500 vehicles and twice that number of personnel. For services in France he was awarded the D.S.O. in 1917.

In January, 1919, Major Kuhne was recalled to London as Deputy Assistant Director of Transport, and appointed a member of the War Office Tractor Committee. In the same year, he was awarded the O.B.E.; but, in January, 1920, he relinquished his commission and took a position as assistant sales manager of Messrs. Armstrong-Siddeley Motors, Limited, Coventry, subsequently becoming manager of their London depot for the final testing and distribution of cars intended for the London area and for export. This appointment did not last long, however, for, in April, 1921, he was again in uniform, having received a Regular Army commission as Captain, R.A.S.C., and being transferred almost immediately to the Royal Army Ordnance Corps as an Ordnance Mechanical Engineer. During 1923-4, he was instructor in the Mechanical Transport School, Aldershot; and, for the next two years, Staff Captain at the War Office, where he was engaged in the development of Army mechanisation. In 1927, he was appointed Deputy Assistant Director of Mechanisation, a position which he retained until 1931, by which time he had attained

the brevet rank of Lieutenant-Colonel. The next four years he spent as Chief Ordnance Mechanical Engineer in the China Command, with headquarters at Hong Kong. On returning, he was confirmed in his rank of Lieut.-Colonel and appointed Senior Ordnance Mechanical Engineer at Aldershot. Latterly, he had been Deputy Assistant Director of Transport, with the acting rank of Colonel.

Colonel Kuhne was a member of the Institution of Mechanical Engineers, which he had joined as an associate-member in 1923, and of the Institution of Automobile Engineers, and had delivered several papers on Army mechanical transport before these institutions and the Institute of Transport. His paper before the Automobile Engineers, in 1928, was awarded the Crompton Medal; and, in the same year, he received the Gold Medal of the Institute of Transport. He served for two years (1931-32) on the Council of the Institution of Mechanical Engineers, while an associate-member, and is the first loss sustained by the small band of associate-members, past and present, who possess that distinction. They, and very many others in Service and civilian engineering circles, will remember with high regard an officer and an engineer of particular ability, whose gift for friendship was not the least of his attributes.

MR. JAMES BROWN, C.B.E.

WE regret to record the death, on January 14, of Mr. James Brown, C.B.E., the managing director and deputy chairman of Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock. Mr. Brown, who was a native of Kirkcudbright, was in his 79th year, having been born on June 15, 1862. His early education was received at Kirkcudbright Grammar School, from 1867 to 1877, after which he attended Glasgow University for two winter sessions. In March, 1881, he was apprenticed to Messrs. A. and P. Steven, Provanside, Glasgow, with whom he served for five years, concurrently taking a course of evening classes at the College of Science and Arts, Glasgow. He was awarded a Whitworth Scholarship in 1886 and, in the same year, on completion of his apprenticeship, entered the engine drawing office of Messrs. J. and G. Thomson, at Clydebank, with whom he remained for three years. In 1889, he went to Spain as assistant manager with Messrs. Astilleros del Nervion, Bilbao, being subsequently appointed manager. He returned to England in 1900 to take a position as works manager with Messrs. Palmer's Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne. After holding this post for three years, he left to become engineering manager for Messrs. Scott's, with whom the rest of his life was spent. He was made a director in 1905, eventually becoming managing director and deputy chairman, as stated above. During his long service with the firm, he was associated with many notable developments, including the construction of the Laurenti type of submarine, the evolution of the Scott-Still marine engine, and the application of Diesel-electric propulsion to ships. He was made a C.B.E. in 1918.

Mr. Brown took a prominent part in technical affairs outside of his immediate interests at Greenock, notably in connection with the Shipbuilding Employers' Federation, the Association of Engineers and Shipbuilders, the Iron Trades' Association, and the Royal Technical College, Glasgow, of which he was a governor. He was a member of the Committee of Management of Lloyd's Register of Shipping, and of the Worshipful Company of Shipwrights. All his life he had been a steady supporter of technical institutions. The Institution of Engineers and Shipbuilders in Scotland admitted him as graduate in 1886, and made him a member in 1892. His membership of the North-East Coast Institution of Engineers and Shipbuilders dated from 1891, and of the Institution of Naval Architects from 1894. Of the latter institution he became a Member of Council in 1912, a vice-president in 1926, and in 1937, an honorary vice-president. He had been a member of the Institute of Metals since 1910, and of the Institution of Civil Engineers since 1917. He joined the Institution of Mechanical Engineers in 1920, and served on the Council for several years.

THE ORIGIN OF GAUGES FOR WIRE, SHEETS AND STRIP.*

By DR. H. W. DICKINSON and HENRY ROGERS, M.B.E.

WIREDRAWING in the true sense of the word, that is, drawing a rod of metal (prepared in early days by shearing or slitting sheet metal and hammering it as round as possible, or in later days by rolling) through successively smaller holes in a tempered steel plate ("draw plate," "drawing iron," or "wortle"), dates back certainly to the Fourteenth Century, and probably earlier. Indications point to the fact that the art was practised in or near Nuremberg in the latter part of that century. The art was practised about the same time in Coventry, Bristol, London and York. In the first-named town, by 1435, the guild of wire-drawers had been incorporated and its constitution discloses division of labour which must have required a long period to grow up. It embraced smiths who hammered the sheared metal; brakemen, who drew the resulting rod through a coarse "wortle"; girdlemen or girdlers, who annealed the wire; middlemen, who removed the scale for the next draw; card wire-drawers, who drew the wire through a fine wortle to the size required by the card-maker; crookers, who cut the wire into short lengths and bent them; and card-makers, who, from these crooks, made the hand-cards.† Wortle making is recorded as a trade as early as 1430.‡

It is a fair assumption that the amount of draft or extension that can be given to a wire at each draw can only have been found out empirically. We may assume that originally each successive hole represented the utmost extension it was possible to give to the wire without breaking it, with intermediate annealing, when hand power alone was available. Even after water power was employed for drawing—a date not known, but believed by Longmuir to be 1624—the gauges might well remain unaltered. There is evidence to show that gauges were in use to guide the workman in drifting the holes in the draw-plate before tempering, and that they were transmitted almost as heirlooms from father to son. What they were like can be inferred from the earliest description§ known to the writers: "Great part of the dexterity of the workman consists in adapting the hole to the wire; that the wire may not pass so easily as not to receive sufficient extension, or so difficultly as to be broken in the drawing. For determining this point with greater certainty than could be done by the mere resistance of the wire, he uses a brass plate called a size, on which is measured, by means of notches like steps cut at one end, the increase which a certain length of wire should gain in passing through a fresh hole; if the wire is found to stretch too much or too little, the hole is widened or contracted. As the extension is adjusted by this instrument, there are others for measuring the degree of fineness of the wire itself: slits of different widths made in thick polished iron rings, serve as gauges for this use."

Lewis goes on to describe the well-known technique of drawing wire through a plate by means of manual power on drums with levers or handles for turning them; throughout, the reference is to gold wire, but we can assume that the same technique was true of iron, probably the first metal to be drawn into wire in this country, and followed by copper and brass wire, some time in the Sixteenth Century. The above description of the "size" corresponds with that of a gauge illustrated by Hughes‖ and used, apparently, within his own experience. The writers are not aware of the existence of such a gauge at the present day. The gauge "for measuring the fineness of the wire" was simply a steel ring with a radial slot through it.

The difficulty remained of getting the hole in the draw-plate to correspond with the size of the wire, and of counteracting the increase in size of the hole caused by continued use; these difficulties were got over either by drifting the hole larger or by punching the steel around the hole to make it smaller. Each wire-drawer had his own gauges and supplied wire to them, probably only few in number. Starting with rods, roughly $\frac{1}{4}$ in. in diameter, known as "0," the range of sizes was gradually extended or widened, not necessarily by the same wire-drawer, till it embraced Nos. 1 (say 0·3 in.) to 26 (0·02 in.). Hughes, after a long search, failed to find a wire gauge made before 1842 with more than that number of sizes. The drawing of wire for card making was a separate trade known as "fine-drawing," with a wire gauge of its own. We have heard of a "Yorkshire" gauge of 1809 and of Billinge's gauge of 1816, afterwards known as Townley's.

Eventually, as power and skill increased, the range was enlarged to 4/0 on the one hand and to 36 on the other. The 4/0 gauge wire was usually made from slit brass $\frac{3}{8}$ in. by $\frac{3}{4}$ in., annealed, groove-rolled on edge to roughly $\frac{1}{16}$ in. in diameter, again annealed, and drawn on the wire block to $\frac{13}{32}$ in. (0·407 in.). When sizes above 4/0 were called for they were made from rolled or bench-drawn brass; not slit, as slitting thick sizes often resulted in defective work if the slitters were not kept in perfect order. Sometimes wire was drawn to weight, the wire being gauged from time to time to detect irregularities in the bundle. This was the case, at any rate for brass wire, at Oakamoor, Staffordshire, between 1805-1811.* At the present day there is little "art and mystery" left about wortle making; it is carried on like other tool making, with the aid of the micrometer. The passing of one of the old firms, that of Peter Finney and Sons, of Aston, Birmingham, is recorded in 1919.†

As thinner and thinner sheets, *e.g.*, of brass and copper, were called for, particularly below 0·01 in. thick, and the speed of rolling increased from about 50 ft. to 80 ft. or 100 ft. per minute, great quickness and dexterity on the part of the roller were required to use a notch gauge while the strip was passing through the gap. Consequently, it has been the custom to provide the roller with an adjustable thickness gauge known in the mill as a "catchem"; this he holds in the right hand opposite to the strip as it leaves the rolls and before it is wound into a coil. If the gauge will not go, he tightens the screws to force the rolls down, and if the gauge goes too easily, he eases the screws. The catchem is becoming obsolete owing to the introduction of a micrometer with a dial, by means of which quick readings can be obtained. Another reason for the use of the micrometer is the trade practice, now greatly on the increase, of ordering sheets by weight, either per square foot or for a given size of sheet.

As soon as the wire-drawer was able to guarantee the sizes of the wire he produced, merchants and customers would want to know them so as to be able to specify and get what they wanted. Hence a gauge for the latter would become a desideratum. This gauge consists‡ of a rectangular plate of steel into the edges of which are cut numbered notches or slots of diminishing widths ending in round clearing holes. May we look upon this as the forerunner of our "Go" and "No go" gauging? Thus, as early as 1783, the obvious device of using numbers for sizes had come in; how much earlier is not known. It seems probable that, at some time later than this, mechanicians began making gauges for the trade, and it would be natural for them to bring together into one instrument all the sizes that they found were being drawn by a number of makers. The rectangular shape of the gauge, with the corners cut off or rounded, has persisted. Hughes had in his possession a gauge of oval shape, with 14 holes, that had been used for fine numbers, dating from the Eighteenth Century. A circular gauge with a central hole and slots around the circumference is used in France and may have originated there.

Charles Holtzapffel, the well-known mechanician, was an early maker of notch gauges and he describes§ how he made them: "Gauges . . . are usually thick plates of steel of several sizes and forms around and near the edges of which are first drilled various holes; the next step is to saw a notch from the edge into every hole, saws of the widths of the several notches being used; and lastly, little parallel plates of steel called drifts, which are hardened and tempered, are driven into the notches in order to smooth the sides of the same and render them of uniform width, after the manner of various other applications of drifts." Presumably, the gauges were then hardened and the notches lapped to dead size.

(To be continued.)

EXPORTS TO EIRE.—The Export of Goods Control (No. 1) Order, 1941, which was issued on January 8 and came into operation on January 20, will have the effect of placing Eire in the same position as other countries in the British Empire in respect of the control of the export of goods from the United Kingdom. Hitherto, it has been possible to give Eire special treatment under which only a short list of goods required licences before they could be exported from the United Kingdom to Eire, but the need for conserving supplies now makes it necessary to withdraw this concession.

* Paper presented to the Newcomen Society, January 15, 1941. Abridged.

† *Coventry Leet Book* (1420-1555), 1912. Edited by M. D. Harris. This affords much information on the early industrial history of Coventry.

‡ *Coventry Leet Book.* Quoted by P. Longmuir and J. Kenworthy: "Notes on Early Wiredrawing Practice," ENGINEERING, vol. 95, page 540 (1913); this is a valuable paper.

§ *Commercium Philosophico-Technicum; or, The Philosophical Commerce of Arts.* By William Lewis (1763).

‖ *The English Wire Gauge.* By Thomas Hughes (1879). This is a most valuable examination of the wire gauge question.

* *Trans. Newcomen Soc.*, vol. xv, page 107.

† *The Ironmonger*, June 7, 1919.

‡ *Encyclopédie Méthodique*, 1783; art. *Aiguillier* (Needle-maker).

§ *Turning and Mechanical Manipulation*, vol. 11. App. page 1011 (1856).

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, NEW YORK.

THIRTEEN papers were presented for discussion when the Society of Naval Architects and Marine Engineers held its 48th annual meeting in the Waldorf-Astoria Hotel, New York, from November 13 to 16 last. Following our practice in previous years, we commence below a series of short summaries of the papers.

ROLLING AND LURCHING.

The first paper, "Notes on Rolling and Lurching—A Proposed Criterion," was contributed by Mr. E. H. Rigg (honorary vice-president), naval architect of the New York Shipbuilding Corporation, who prefaced his remarks with the explanation that "lurching" denoted "deep rolls well beyond the normal and not readily explainable"; and that he proposed to discuss the causes which produced a tendency to such rolls or lurches, and to attempt to find a method by which this tendency might be forecast and avoided as much as possible. A maximum operation GM of 6 per cent. of the beam, Mr. Rigg proceeded, had been considered as a tentative standard for passenger ships, and somewhat less for smaller ships. Using this as a base, stiffness could be plotted in terms of GM expressed as a percentage of beam, using 6 per cent. as 100. The higher the numeral, the shorter the rolling period; thus relative stiffness could be measured as the period and the GM varied. For a GM representing 5 per cent. of the beam, the stiffness was 92; for 4 per cent., 82; for 3 per cent., 71; for 2 per cent., 58; and for 1 per cent., 41. For normal rolling, this relationship might be considered representative, but, for application to particular ships, the radius of gyration K should receive attention so far as comparative data were available. More information was needed for K values, which varied from ship to ship, from voyage to voyage, and during a voyage.

From time to time, rolling tendencies had been discussed in terms of height of metacentre above waterline, (beam)^2 divided by draught, distance between centres of buoyancy and gravity, ratio of BM to GM, and acceleration at the end of a roll. After considering all these features, Mr. Rigg put forward a formula which, he believed, would give a good measure of the liability to lurching, this criterion being

$$C = \left(\frac{\text{beam}}{K}\right)^2 \times \frac{BG}{d} \times \frac{1}{a}.$$

The term a represented the immersed midship-section area divided by the area of a semi-circle of radius equal to the draught, and gave a rough comparative measure of the resistance to rolling due to form. In using such a term, it was pointed out, care should be taken not to compare directly a ship with bilge keels and one without; normal bilge keels were assumed. The term $(\text{beam} \div K)^2$ was constant for similar ships. Each type would give reasonably constant values within itself, although different types would show considerable variation. A typical modern large passenger ship would show a value of about 6, increasing to 10 for smaller ships of this type. The term $(BG \div d)$ reflected the disadvantage of a large B G and the advantage of the deeper draughts. The solution of the equation on a base of GM expressed as a percentage of beam, taking the GM = 6 per cent. beam as 100, showed for a 5-per cent. GM, 105·6; for 4 per cent., 110·8; for 3 per cent., 116·5; for 2 per cent., 121·6; and, for 1 per cent., 126·3. The corresponding actual values of C were 2·13, 2·25, 2·36, 2·48, 2·59 and 2·69. When the values for the lurch criterion were plotted with those of the stiffness criterion on a common base of GM expressed as a percentage of beam, the vertical distance between the two curves, it was considered, gave a good practicable indication of the tendency to lurching. It should be noted, said Mr. Rigg, in conclusion, that a base could be assumed at any GM relative to beam; 6 per cent. was not a fixed point. For most types of cargo ships, it would be too high, and also for the smaller passenger ships.

THE CALCULATION OF MOTION AND STRESSES DURING PITCHING AND HEAVING.

Professor H. L. Hazen and Mr. P. T. Nims presented the second paper, on the "Calculation of Motion and Stresses of a Pitching and Heaving Ship," the chief interest of which lay in its use of a new type of calculating machine, the "cinema integraph," which enabled the computations to be made with fewer arbitrary assumptions than had been necessary previously. This apparatus is designed to integrate rapidly the product of two functions (in this case, the hull-form function and the pressure-gradient function in the wave), the graphs of which are formed on a strip of motion-picture film. Shears and moments were similarly computed from the actual longitudinal distribution of buoyant force, the approximate damping forces and the accelerations in pitch and heave. The resultant accuracy, the authors stated, far exceeded that of the underlying assumptions and was adequate to permit useful engineering comparisons of the calculated stresses among different ships and conditions of loading and sea. The ship used in developing the methods described in the paper had a hull of destroyer form. Application of the elementary laws of translation and rotation yielded the heave and pitch equations, a linear damping or resistance force being arbitrarily assumed. These equations were then integrated numerically by the methods commonly applied to the oscillatory motions of synchronous electrical machines. The total buoyant force was obtained by the summation of the forces acting on successive transverse sections of the hull, and the buoyant pitching moment was similarly derived from the assumed trochoidal wave formation, the wave film being shifted one frame with respect to the hull film and the buoyant moment and force obtained by means of the intergraph until the complete periodic motion of the ship was computed. Once the motion was known, the stresses were obtained by determining the net force which the adjacent portions of the hull must exert jointly on any given unit length of hull, the hull being considered as a slim rod with distributed mass, subjected to distributed buoyant and resistance forces and to heaving and pitching accelerations. The cinema integraph was found to have an error of well under 1 per cent., with skilled operation and typical functions, and pre-supposing correct arithmetic; but the time occupied in the calculations was such that, in the authors' opinion, its principal use was likely to be in the study of type problems and important individual ships, rather than in routine design. For this research type of problem, however, the method appeared to have much promise.

ADDED WEIGHT AND LONGITUDINAL STRENGTH.

The third paper in the programme, by Mr. L. W. Ferris, dealt with "The Effect of an Added Weight on Longitudinal Strength." Mr. Ferris observed that alterations in design or in existing ships, involving the addition or elimination of local weights, were often insignificant in their effect on the ship's strength; but there were some cases in which strength considerations required attention, especially with lightly-constructed vessels. A concentrated weight in conjunction with a distributed buoyancy produced a bending moment in the hull; and the addition of a further concentrated weight amidships would cause a change in the midship bending moment of a sagging nature, tending to put the deck in compression and the keel in tension. In computing the effect of an added weight P, at a distance from amidships, it was convenient to assume that P was first added at midlength and moved along the deck to its final position, the ultimate effect on the midship bending moment being found by summing up the new bending moments, developed between the midship section and the end of the vessel towards which the weight was moved. The movement would cause a wedge of the hull to be immersed at that end, and a corresponding wedge to emerge at the other end. If the vessel were considered as poised on the crest of a wave, or supported between two waves in the conventional manner, the shapes of the wedges would differ slightly, but the difference would be negligible for the small height of wave in relation to the length of hull. The arguments for the still-water hogging and sagging moments therefore held. The effect of sliding the weight P through a distance x was to cause an increase in hogging moment of $P\,x$, due to the weight itself, and a decrease in hogging moment of $\frac{P\,x}{2}$, due to the buoyancy of the immersion wedge, the combined effect being that

$$\Delta M = \left(\frac{P\,x}{2} - \frac{P}{2} k \frac{l}{2}\right).$$

For the sagging condition, the formula was the same, but with a larger value of k to suit the sagging sinkage layer, which was fuller at the ends. The total wedges of immersion and emersion in a given case must necessarily be equal in volume, but the centre of gravity of each was located and the weight of the immersion wedge determined in terms of P, the distance between the centres of gravity being the arm of the buoyancy couple by which the trimming moment, due to the shift of P, was resisted. Typical values of k, for hogging and sagging, were given in the paper for a cruiser, 578 ft. long; a destroyer, 341 ft. long; a battleship, 600 ft. long; and a tanker, 455 ft. long. An average value of k for hogging was found to be about 0·35, and, for sagging, about 0·45. The author pointed out that, if the added weights were such that the sinkage and change of trim caused very radical changes in the waterline, there seemed to be no course but to rebalance the ship on the wave and replot the curves of shear and bending moment, to get accurate results; but, if the waterlines were not radically changed, the formula could be recommended. In view of the artificial nature of the whole longitudinal-strength calculation—the assumed proportions of the wave, the assumed static balancing of the ship on the wave, and the calculation of stresses by the beam formula—it was apparent that no great degree of precision was justified in calculating small changes in bending moment.

STRUCTURAL CHARACTERISTICS OF THE DESTROYERS "PRESTON" AND "BRUCE."

The fourth paper, by Commander C. O. Kell, U.S.N., was a continuation of a paper presented before the Society in 1931, in which were given descriptions of the static-strength tests conducted on the two destroyers Preston and Bruce, the procedure followed, the methods employed in the collection of data, and the instruments used. This second part of the paper contained a description of the methods of analysis and a discussion of the results. Before beginning the analysis, said Commander Kell, the records were checked against the original data to eliminate possible errors in copying, several of which were found among the strain-gauge readings. In interpreting the data obtained from the tests, it was necessary to bear in mind that they were static tests, and that no dynamic forces, such as a ship experienced in a seaway, were represented. Further, it was not possible to represent the torsional forces to which a ship at sea was subjected. Whether or not the ships' structures would function at sea as they did in the tests, was a question remaining to be answered. It was possible that the results obtained by Dr. G. Schnadel and his associates on the M.S. San Francisco would answer this point; they had found that all continuous structure was effective in the formation of the section moduli, and no allowance was made for rivet holes. The non-representation of torsional forces was important because, had it been possible to introduce such forces along with bending, no doubt a different stress distribution would have been found, perhaps together with weaknesses in shear other than the wrinkling of plating. The detailed stress measurements showed that the simple beam theory could be used with accuracy in predicting stress in the structure in designing. This was particularly true in the case of longitudinal stresses resulting from sagging and hogging.

There remained some things to be explained in the distribution of shear stresses, although it had been found that shear stresses calculated by the approximate formula were on the safe side. It remained to be determined, also, what were the functions of longitudinals, machinery foundations, platform decks, and transverse bulkheads, in carrying a part of the shear load. The disagreement between measured shearing stresses and the theoretical stresses calculated by the complete formulæ was not explained. In further discussion of the distribution of shear stresses found in both tests, the author referred to Dr. J. Lockwood Taylor's paper on the subject, delivered in 1924 before the North-East Coast Institution of Engineers and Shipbuilders. In stations where the theoretical shearing forces were zero, finite shearing stresses were measured in the shells of the ships; but these were so small as to make their correct value questionable because of possible errors in measurement and, for that reason, they were not plotted.

The data cleared up all the questions that were raised over the results of Sir John Biles' tests with H.M.S. Wolf with reference to the disagreement of theoretical and observed deflections, the modulus of the structure, and what structure should be included in the calculation of section moduli. They showed that all continuous structure, and that with reasonable fore and aft length, was effective, and that no allowance need be made for rivet holes. Because of the light construction of the Preston and Bruce, it was believed that the same practice should hold for ships with heavier scantlings, if the plating were properly supported. The modulus of the structure was found to be that of the material. It was questionable, however, whether a modulus of structure equal to that of steel could be accepted for ships having heavier plating, unless the butts of longitudinal strength members, and those of the shell plating, were welded. The details of the failures and of the stresses at failure could be accepted as applicable only to the design of the destroyers considered. The weakness of both the deck and the bottom structure, when loaded in compression, and the effect of discontinuity of structure, was demonstrated. Instability of the structure because of inadequate support was the cause of failure in each case. In addition to the need for adequate stiffening of plating, the questions of the rigidity of the stiffeners themselves, their stability under compression, and the importance of details of connections of the stiffeners to the plating which they supported, were clearly brought out by the tests.

(To be continued.)

HAND-OPERATED CARBON-ARC WELDING TORCH.

THE compact carbon-arc welding torch shown in the accompanying illustration has recently been introduced by Messrs. Siemens-Schucket (Great Britain), Limited, Great West-road, Brentford, for hand operation on light sheet-metal work where short and irregular runs in medium quantities are required. Such work often involves the making of edge and corner joints, and these are readily dealt with by the carbon arc, which is essentially a fusion-welding process. Longer and more straightforward runs in large quantities are, of course, dealt with by automatic or semi-automatic carbon-arc welders. The torch may be used with any direct-current welding set and is made in two sizes, the smaller having a current range of from 15 amperes to 80 amperes, and the larger a range of from 40 amperes to 160 amperes. The small torch will accommodate carbons $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in diameter, and is suitable for sheet-metal work up to $\frac{1}{8}$ in. thick; this size is shown in the illustration. The large torch is suitable for carbons $\frac{5}{16}$ in. to $\frac{1}{2}$ in. in diameter and for work up to $\frac{1}{4}$ in. thick. Both sizes are self-adjusting for different carbon sizes. The normal carbon consumption is $\frac{1}{2}$ in. per foot run of seam. The arc is held steady by

a powerful blow-coil in the carbon holder. The method of handling the torch will be clear from the figure, but it may be mentioned that, in addition to keeping down the weight to the practicable minimum, the question of balancing has been carefully considered so as to avoid, as far as possible, fatigue to the operator. No filler wire is required.

INSTITUTE OF METALS.—As already announced in our columns, the 33rd annual general meeting of the Institute of Metals will be held at 4, Grosvenor-gardens London, S.W.1, on Wednesday, March 5, at 2.30 p.m. The purpose of the meeting will be to consider the Report of the Council, for the year ending December 31, 1940, the Treasurer's Report and statement of accounts for the year ending June 30, 1940, and the election of officers, members of Council, and auditors for the year 1941-42. The meeting will be of a formal character and no papers will be presented or discussed.

"INGENUITY" COMPETITION.—The Council of the Institution of Civil Engineers invite papers from corporate members and students for a prize of 25 guineas, which will be awarded for a description of an engineering problem and the method adopted to solve it. The paper should not exceed 2,000 words, and must describe a specific problem involving immediate action and ingenuity displayed in meeting it. The problem must have arisen in the competitor's own experience and the action taken must have been to some extent—not necessarily wholly—his own idea. These facts must be vouched for in a satisfactory manner. The papers should reach the Institution by April 30, 1941, and the manuscript should be marked "Ingenuity" Competition in the top left-hand corner of the first page. The Council reserves the right to publish the winning entry or any other selected entries, and should such entries relate to engineering problems arising out of the war the Institution would submit them to the Censor before publication.

LABOUR NOTES.

IN the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in November are estimated to have resulted in an increase of nearly 70,000*l.* in the weekly full-time wages of 661,000 workpeople and in a decrease of about 8,000*l.* in those of 220,000 workpeople. The workpeople whose rates of wages were reduced had received increases of greater amount during earlier months of the year. The principal groups of workpeople affected by the increases were those employed in pottery manufacture; iron and steel manufacture; heating, ventilating and domestic engineering; the woollen industry in Yorkshire, and the milk distribution trade in England and Wales. Among these, pottery workers received increases of 4*d.* a day in the case of men, 3*d.* a day in the case of women, and 2*d.* a day in the case of juniors; workpeople employed in iron and steel manufacture in various districts received increases of 1·6*d.* a shift for men and 0·8*d.* a shift for youths and boys; skilled craftsmen and adult mates and assistants employed in the heating, ventilating and domestic engineering industry obtained an increase of ½*d.* an hour; in the wool textile industry in Yorkshire, rates of wages were raised by approximately 8½ per cent. in the case of timeworkers, and by 7½ per cent. in the case of pieceworkers; and in the milk distribution trade in England and Wales the minimum rates fixed under the Trade Boards Acts were increased by 3*s.* a week for men and women, and by 1*s.* 6*d.* or 2*s.* a week for juveniles.

Other groups of workpeople whose rates of wages were increased included coal miners in Leicestershire, ironstone miners and limestone quarrymen in various districts, tin-plate workers, tobacco workers, bakers in some districts, and journeymen and assistants employed by electrical contractors in England and Wales and in Northern Ireland. The decreases in rates of wages affected coal miners in Yorkshire, Derbyshire, Cannock Chase and Warwickshire, and were due to the operation of sliding-scale agreements under which wage rates fluctuate in correspondence with the ascertained proceeds of the industry. The changes so far reported in the eleven completed months of 1940, in the industries for which statistics are available, are estimated to have resulted in a net increase of nearly 2,000,000*l.* in the weekly full-time wages of about 7,800,000 workpeople.

At November 30, the official cost-of-living index figure was 95 per cent. above the level of July, 1914, as compared with 92 per cent. at November 1. For food alone, the index figure at November 30 was 73 per cent. above the level of July, 1914, as compared with 72 per cent. at November 1. Among items other than food there were increases averaging about 5 per cent. in the prices of clothing, partly due to the operation of the Purchase TAX. There were also increases in the prices of coal in many towns.

The number of trade disputes involving stoppages of work, reported to the Ministry of Labour and National Service as beginning in November, was 79. In addition, nine disputes which began before November were still in progress at the beginning of that month. The approximate number of workpeople involved in the 88 disputes, including workpeople thrown out of work at the establishments where the disputes occurred, was 20,000, and the aggregate duration of the disputes in November was about 48,000 working days.

In December, the home-branch membership of the Amalgamated Engineering Union decreased from 454,669 to 454,126, and the Colonial branch membership from 40,340 to 40,328. The number of members in receipt of sick benefit increased from 4,576 to 4,714, and the number drawing superannuation benefit decreased from 13,474 to 13,380. The number in receipt of donation benefit increased from 490 to 584, and the total number of unemployed members from 2,349 to 2,430. An editorial note in the January issue of the organisation's *Journal* says that notwithstanding the difficulties of the past year, the Union has made remarkable progress. "It is," the writer states, "numerically and financially stronger than it has ever been. We are nearing a peak membership of half a million. Additions have been maintained during 1940 at a very high monthly level. We started the year with a total membership of 413,094. The figures at the close of the year show a net increase of 81,360 for the period."

The *Trade Report* of the United Patternmakers' Association states that, in December, the number of unemployed members of the organisation decreased from 92 to 83. There was, Mr. Findlay, the general secretary, says, "the usual increase at this time of the year" in the number in receipt of sick benefit—270, as compared with 214 a month ago, but 672 as compared with 674 drawing superannuation benefit. The membership is 12,662, and will be 12,679 next month.

A report of a sub-committee of the House of Commons Select Committee on National Expenditure appointed to deal with the Labour problems of the Supply Services directs attention to the amount of overtime worked and its effect on production and costs, and "regrets" to say "that the lessons which the last war should have taught about the effect of overtime on the health and attendance of workers seem largely to have been ignored." "Even before the production drive began last May," the sub-committee go on to say, "employers found that excessive overtime led to unrest, fatigue and sickness and was not good for production. Government factories were also finding that industrial fatigue was setting in which showed itself in an increase in the sickness rate. On the other hand, if a certain amount of overtime was not worked men left their factories for others where they could earn more by working overtime."

"After the invasion of Holland and Belgium," the sub-committee continues, "the Government appealed for extra work and factories were working 24 hours a day, seven days a week. The result at first was an undoubtedly big increase in production, but after two months the expected symptoms began to appear. Absenteeism became much more common and men arrived late. Sunday labour led to men taking a day off in the middle of the week, when they lost only an ordinary day's pay and earned double pay on Sunday to make up for it. The Royal Ordnance Factories' absenteeism rose from 10 to 15 per cent., and at the end of July it was decided, wherever possible, to discontinue Sunday labour and also labour on Saturday afternoon as well. The result was immediate. Time-keeping improved and production did not suffer. The sub-committee was told of one factory where, after the reduction of hours, they set up a new record for one week's production."

"The sub-committee wholeheartedly endorses," it is declared, "the opinions set forth in the document issued by the Ministry of Labour at the end of July, which recommended an immediate reduction of hours to an average of 60 a week, with the aim of a further reduction to an average of 55 or 56 a week as soon as the necessary labour force has been acquired."

The sub-committee states, it will be observed, that even before the production drive began last May "employers found that excessive overtime led to" amongst other ills, sickness. In this connection, it may be noted with interest that at the end of December last only 4,714 members of the Amalgamated Engineering Union were in receipt of sick benefit out of a total membership of 494,454. At the same date, 270 members of the United Patternmakers' Association out of a total membership of 12,662 were in receipt of sick benefit.

Miss C. Haslett, adviser to the Ministry of Labour and National Service on women's training, spoke last week at the Royal Society of Arts, on the part that women are expected to take in the war effort. In the course of her address, Miss Haslett said that the general attitude of the community to women's work required revision. In many fields of employment women were too little used. Women omnibus conductors, though many of them were expert at their jobs, would find that employment closed to them again after the war. No doubt, as in the last war, many women would discover that their real vocation was engineering and neither dressmaking nor teaching. Was it too much to ask that a very small field of opportunity should be left to such women when hostilities ceased? The ordinary means of entering engineering employment were barred to women, and no woman, whatever her qualifications, could serve an apprenticeship in the ordinary way. The whole community would be up in arms if any human being were excluded from employment because of his nationality, his social standing, his place of education, and yet no one was really surprised that women were excluded on account of sex.

It is announced that Sir William Beveridge, who has been chairman of the man-power survey of the Ministry of Labour and National Service has been appointed an Under Secretary in the Ministry. He fills a vacancy caused by the retirement of Sir James Price who, having left the Ministry before the war, returned to take up war-time duties. He resigned from the Ministry a few days ago.

THE ENGINING OF HIGHLY POWERED SHIPS.*

By SIR STEPHEN J. PIGOTT, D.Sc.

IT has been stated that romance in ship propulsion held only with full-rigged sailing vessels, and was lost with the coming of mechanical propulsion; but it can be contended that the working of the open-type steam engine held the interest of many passengers. This contention is supported by the attention given by designers to rendering the entrance to the engine-room attractive, and the engine-room platform sufficiently spacious to accommodate those inspired by interest in the workings of mechanical propulsion. The turbine, with the working parts apparent only as cylindrical masses, did not sustain this general interest.

While the class which may be termed "highly-powered ships" is a very small part of the world tonnage, and could be virtually neglected in any mass consideration of the problem of ship propulsion, the necessity of providing suitable propelling machinery for such ships has played an important part in the progressive advancement in ship propulsion. By reason of the magnitude of the power required, the suitability of the methods of propulsion is more narrowly prescribed in highly-powered vessels. The progressive development of mechanical propulsion of highly-powered ships has been confined to four general methods of power transmission, namely:—Reciprocating steam engines, steam turbines directly connected to the propeller shafting, steam turbines mechanically geared to the propeller shafting, and turbo-generators transmitting power electrically to motors directly connected to the propeller shafting. With each of these methods, much ramification has occurred, dictated by such considerations as progressive development, conditions of application, conditions of the particular service, and the striving for increased economy in the use of fuel.

Until the beginning of the present century, the reciprocating type of steam engine, with steam supplied generally by boilers of the cylindrical fire-tube type, satisfied all demands for highly-powered ships, and it would seem that the interest in mechanical propulsion reached the highest pitch through the stimulus of the international struggle for speed in Atlantic crossings, and the honour of holding the much coveted Blue Riband. For approximately three score years, this honour was successfully maintained by the progressive development of vessels of British and American ownership, changing hands in 1897, when the performance of the Campania was surpassed by that of the German-owned Kaiser Wilhelm Der Grosse. Then followed the Deutschland and the Kaiser Wilhelm II, to retain this coveted honour in German hands for some ten years. These multi-cylinder engines marked the highest power and development of the steam reciprocating engine, and may be considered the acme of the mechanical engineering art of the Nineteenth Century. The Kaiser Wilhelm II was a twin-screw vessel having two three-crank quadruple-expansion engines on each shaft, arranged as shown in Fig. 1, on Plate VI. Table I, on this page, enables ready comparison to be made of the general features of these mammoth mechanisms, which attained to approximately 50 ft. in height.

It is a far cry from the earliest recorded application of the rotative force of steam pressure, in the primitive working of virtually a toy mechanism, to the practical application of this same force in the latter years of the Nineteenth Century as a real rival to the highly-developed reciprocating steam engine. It was at this critical moment in marine engineering history that the Hon. C. A. Parsons astonished the world with the performance of the Turbinia, and opened the door to a new era in marine propulsion, the limits of which have yet to be realised. This principle of rotative force did not lie entirely dormant throughout those centuries, and there is evidence that the possibilities were recognised by James Watt. In explanation of the long delay in the practical application, it has been stated that the machine tools available in those earlier years could not give the accuracy in finish necessary in an engine dependent upon high speed of rotation for economical service. Developments, even in recent years, indicate that progress in the perfecting of machine tools has greatly influenced, or has actually dictated, the progress in the development and transmission of power.

In his lecture, entitled "Sir Charles Parsons and Marine Propulsion," before the Institution of Mechanical Engineers, in 1938, Mr. Stanley S. Cook ably and very fully covered the earlier developments of the reaction turbine for ship propulsion, and it is not intended to attempt in this lecture any elaboration; but mention will be made of the similar development of the marine impulse turbine by Charles G. Curtis, begun in the United States of America in the early years of the present century and subsequently extended to the propulsion of notable ships, constructed in Great Britain and on the continent of Europe.

The propelling installations of the Lusitania and the Mauretania must hold place as the most highly-powered type of direct-coupled turbine drive in merchant vessels. For the engineer of to-day to appreciate fully the development of propulsion of these mighty ships, it is necessary that he should realise the genius, courage and tenacity of the late Sir Charles Parsons, in beginning with the construction of the radial-flow turbine of the Turbinia, persevering through the misfortunes of the Cobra and the Viper, and progressing with relatively low-powered naval and mercantile installations to the Carmania of 21,000 shaft horse-power (see Fig. 2, on Plate VI), and then the drastic increase to the installations of 70,000 shaft horse-power fitted in the Lusitania and the Mauretania, shown in Fig. 3, on same Plate. To appreciate how meteoric was the rise of the marine steam turbine, it should be noted that, whereas the power of reciprocating installations increased from 5,000 to 45,000 indicated horse-power in a period of 50 years, the power of turbine installations increased from about 9,000 to 70,000 shaft horse-power in about five years.

It may be contended that the confidence of Sir Charles Parsons was well supported by the fulfilment of his expectations in earlier achievements, and that this drastic increase was a matter of degree, which could be substantiated by trustworthy calculations; also, it may be recalled that this enterprise proceeded only after receiving the blessing of a committee of eminent engineers, called together by the Cunard Company for the purpose of assessing what reasonable certainty there was of success. It may also be contended that the other associates of this enterprise, namely, the owners and the builders, had also the findings of this committee to fortify their trust in the recommendations of Sir Charles Parsons; but the engineer of to-day would be guilty of ingratitude did he not appreciate the enterprise and foresight of the then chairman of the Cunard Company—the second Lord Inverclyde—in specifying turbines for the Carmania, while the question of the propulsion of the Lusitania and Mauretania was still under consideration. He must have fully realised, even at that early day, that only through propulsion by turbines could the purpose of these great vessels be achieved.

Through the kind permission of Cunard White Star, Limited, the following abstracts are given from the deliberations of the Cunard Committee appointed to consider and report upon the advisability and practicability of adopting turbine engines instead of reciprocating engines in the new fast steamers:

"The Committee are aware that the makers of several types of turbine engines are prepared to make machinery of their own type for marine purposes. In the course of the enquiry, it soon became apparent to the Committee that, for these large ships, the only type requiring serious attention was the Parsons', this being the only one with which any reliable experience afloat has been obtained.

"At the time the Committee were appointed there was little information available as to the relative economy of turbine engines and reciprocating engines.

"In order to determine the mechanical difficulties likely to present themselves in the construction of turbines of sufficient size to develop the required power, and also to deal with the general question of turbines being fitted in these vessels, the Committee have examined the drawings which have been prepared by the Parsons' Marine Steam Turbine Company. Several modifications in the design have been suggested by the Committee, and the drawings have been altered accordingly.

"The Committee point out that the question on which they are asked to give an opinion is one involving very great changes in the ordinary practice of marine propulsion. At present, few vessels have been fitted with turbine machinery, and the turbines in these vessels are of moderate size only. The most powerful set of marine turbine machinery in use at present is that fitted in the steamship Queen, employed on the Calais-Dover service, which has about 9,000 h.p. applied through three shafts. The proposed arrangement of turbine machinery for the new large ships provides for over 60,000 h.p. applied through four shafts. The Committee wish to emphasise the fact that one of the questions they have to answer is whether they would recommend advancing from machinery of about 9,000 h.p. to machinery of over 60,000 h.p. with a type of engine which has only recently been brought into use afloat, or, in other words, from turbine machinery developing about 3,000 h.p. per shaft to turbine machinery to develop over 15,000 h.p. per shaft. Increase of size with reciprocating engines has only proceeded slowly, and about 40 years were occupied in passing from a horse-power of 5,000 to a horse-power of 20,000 on one shaft.

"As the engines of the highest powered vessel afloat develop about 40,000 h.p., the question now under consideration involves an advance in the total horse-power in one ship from 40,000 to over 60,000. The Committee recognise that the experience gained in the design and manufacture of such high powered reciprocating machinery will be of service in dealing with large turbines.

TABLE I.—ATLANTIC LINERS WITH RECIPROCATING STEAM ENGINES.

—	Campania and Lucania.	Kaiser Wilhelm der Grosse.	Deutschland.	Kaiser Wilhelm II.
Length (b.p.)	601 ft. 0 in.	625 ft. 0 in.	662 ft. 9 in.	678 ft. 0 in.
Displacement (tons)	18,000	20,880	23,620	26,500
Type of engine	Five-cylinder Triple expansion	Four-cylinder Triple expansion	Six-Cylinder Quadruple expansion	Four-cylinder Quadruple expansion, 2 engines in tandem
No. of cranks	3	4	4	3
Diameter of cylinders in each engine	2 at 57 in., 1 at 79 in., 2 at 98 in.	1 at 52 in., 1 at 89·7 in., 2 at 96·4 in.	2 at 36·61 in., 1 at 73·6 in., 1 at 103·9 in., 2 at 106·3 in.	1 at 37·4 in., 1 at 49·1 in., 1 at 74·7 in., 1 at 112·2 in.
Stroke	69 in.	68·8 in.	72·8 in.	H.P., 1st I.P. and 2nd I.P. = 70·8 in. L.P. = 72·8 in.
No. and type of boilers	12 double-ended, 1 single-ended	12 double-ended, 2 single-ended	12 double-ended, 4 single-ended	12 double-ended, 7 single-ended
Steam pressure	165 lb.	178 lb.	220 lb.	225 lb.
Total heating surface (sq. ft.)	82,000	84,285	85,468	107,643
Total indicated horse-power	30,000	30,000	36,000	43,000 (44,600) record voyage
Type of draught	Open stokehold	Open stokehold	Open stokehold	Open stokehold
Highest mean speed on Atlantic passage	22·01 knots	22·79 knots	23·36 knots	23·58 knots

"On the basis of Mr. Froude's report, for a vessel of about the dimensions given, to obtain a speed of 25 knots the horse-power of the propelling machinery to be installed, whether reciprocating engines or turbines are fitted, should be between 65,000 and 70,000. The Committee see no reason why turbines of this power could not be constructed; but they are not in a position to express an opinion as to whether the machinery and boilers can be installed in ships of the dimensions given. Although such turbine machinery would be very much larger than any machinery of that type at present at work, the Committee are of opinion that it could be applied with reasonable expectation of success and absence of vibration, whereas with reciprocating engines, placed in the only available positions in the ships, the vibration would be troublesome.

"The question of vibration if reciprocating engines were fitted has been considered, and it has been found that the engines could not be perfectly balanced even by the largest balancing weights it would be advisable to use. With turbines, however, the vibration due to the engines would be practically nil.

"The advantages which turbine engines would possess over reciprocating engines for the new fast steamers are:—(1) saving in weight; (2) practical absence of vibration; (3) reduction of the engine-room staff; (4) reduction in expenditure of engine-room stores; (5) all machinery, except the eduction pipes and tops of the condensers, below the water, thus rendering the ships more suitable for Admiralty requirements as armed cruisers; (6) reduction in cost of upkeep of engines; (7) the diameters of the shafting outside the turbine being less than those of some shafting in use. If reciprocating engines were fitted, the shafting would be larger than any with which experience either in manufacture or in use on board ship has yet been obtained.

"The disadvantages of the turbine engines as compared with reciprocating engines for these ships are:—(1) the limited amount of experience yet obtained with turbine engines; (2) the great weights of parts to be dealt with in manufacture and overhauling, the heaviest pieces each weighing about 100 tons; (3) the necessity for providing special lifting gear for these heavy

* Sir Charles Parsons Memorial Lecture, delivered at the North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, on December 17, 1940. Abridged.

THE ENGINING OF HIGHLY POWERED SHIPS.

(*For Description, see Page* 78.)

Fig.1.

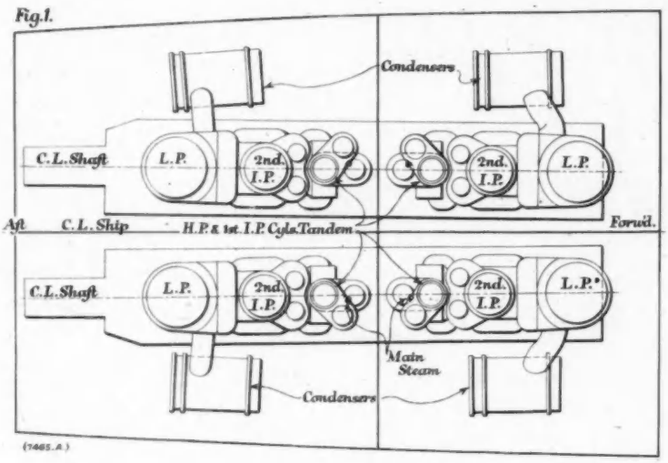


Fig.2.

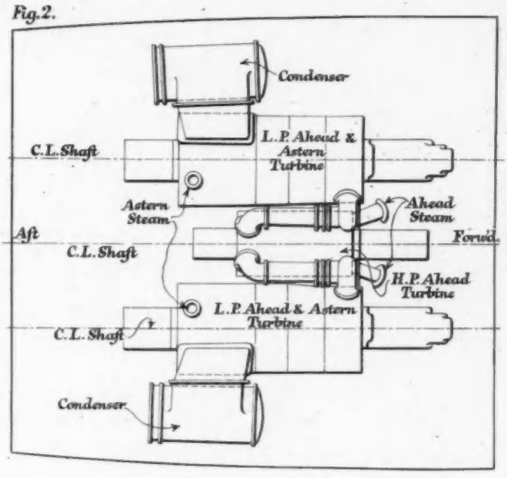


Fig.3.

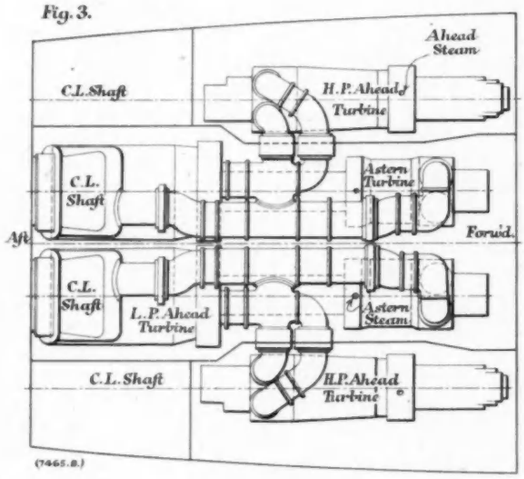


Fig.4.

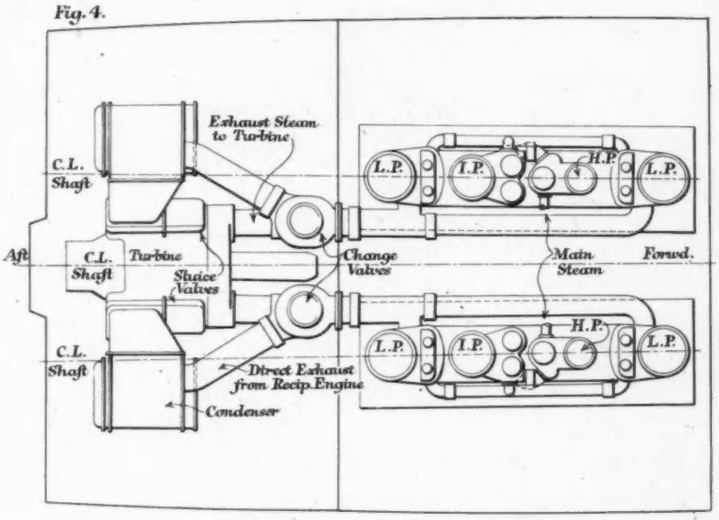


Fig.5.

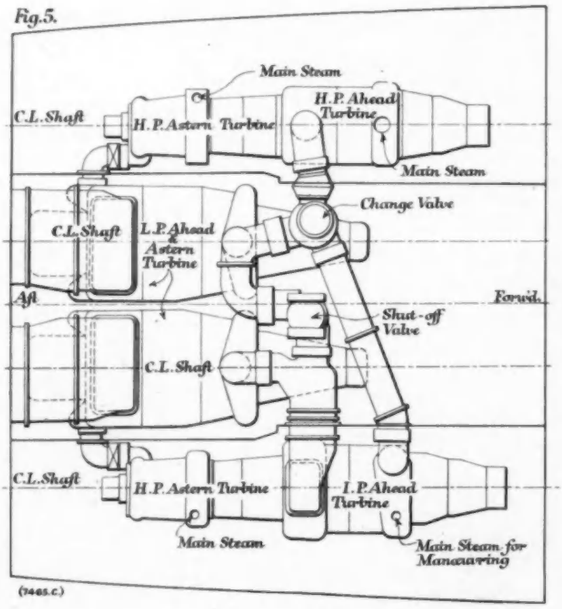
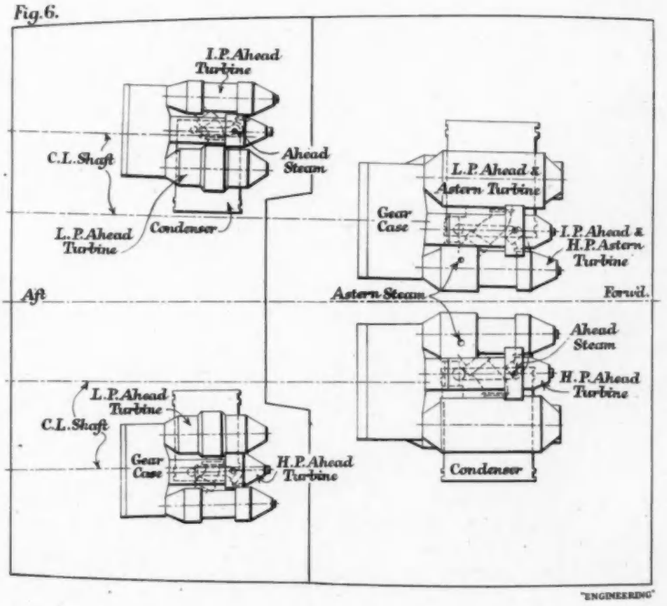


Fig.6.



(*To face page* 78).

UNIV. OF MICH.

TURBINES FOR HIGH-POWERED SHIPS.

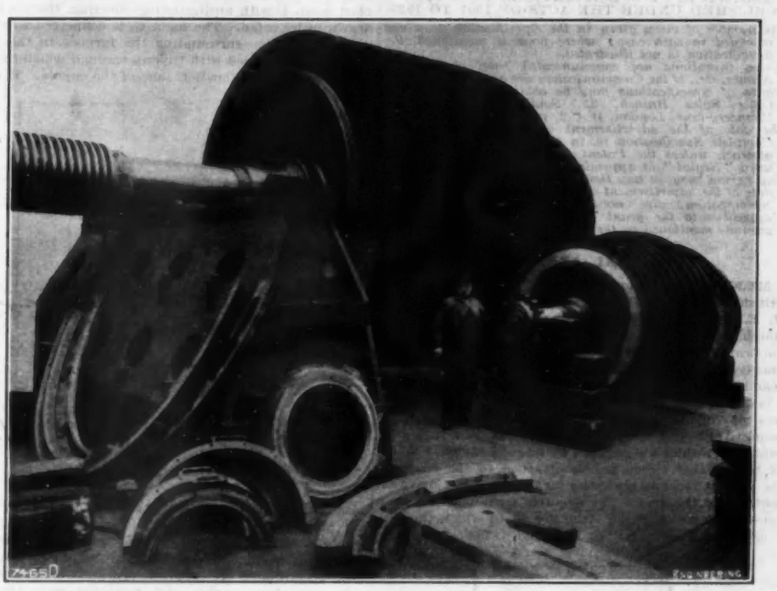


FIG. 7. DIRECT-DRIVE AND GEARED ROTORS, OF COMPARABLE POWER.

weights, and arranging for the removal of the decks overhead to permit of overhauling on an extensive scale being carried out when required; (4) the necessity for the use of four shafts with four propellers, and the fact that the only data at present available from which the efficiency of this arrangement can be judged, are those afforded by tank experiments. The Committee understand that these tank experiments will be supplemented by experiments with the launch before mentioned.

"The manœuvring of these ships will necessarily present special difficulties on account of their great weight and high speed, whichever type of machinery would be fitted. The Committee have considered the question of the probable efficiency of the turbine in this respect, and see no reason for doubting, on the performance of existing turbine vessels, that with the intended provision of power in the reversing turbines, satisfactory results should be obtained.

"The Committee are of opinion that it would be justifiable to adopt Parsons' turbines for these vessels, despite the absence of experience in connection with turbines of such large size, although, as explained above, the step is unavoidably a large one."

In reviewing to-day the conditions obtaining in the last decade of the Nineteenth Century and in the first decade of the present century, it would seem that, had this Cunard Committee demurred in recommending the adoption of steam-turbine propulsion then, the Lusitania and Mauretania would not have eventuated; or, at best, this project of regaining the supremacy in Atlantic crossings must have been deferred until more gradual development and progress would justify this great enterprise. The Carmania cannot be truly rated as a highly-powered vessel, with a total horse-power approximately one-half of that developed by the reciprocating engines of the Deutschland and Kaiser Wilhelm II; but, with the building of the turbine installation for the Carmania immediately preceding those for the Lusitania and the Mauretania, much valuable experience, both in design and production, was gained.

The advocates of the reciprocating engine were not dismayed by the success of the all-turbine ships, and there existed a strong conviction that the higher pressure range could be more economically employed in the cylinders of the reciprocating engine than in the high-pressure units of the all-turbine system, while admitting the more effective employment of the lower pressure range and the fuller use of available vacuum in the turbine. From such deductions resulted the reciprocating engine-turbine combination drive, with endeavour concentrated more on increased fuel economy than on superiority in power.

Among highly-powered ships, the Olympic and Titanic are outstanding examples of this system, with a four-cylinder triple-expansion engine on each outer shaft, and a low-pressure turbine on the centre shaft taking the steam exhausted from both reciprocating engines, as shown in Fig. 4, Plate VI. This system, although more recently employed in the later Laurentic and in the Britannic, has not gained wide popularity, it being contended by many that, while the fuel consumed per horse-power showed improvement over the all-turbine system, the propulsive effort on the ship did not show a similar improvement, due to the lower efficiency of the faster-revolving turbine-driven centre propeller.

While emphasising the rapid development of the direct turbine drive in merchant vessels, it is not intended to minimise the similar, though slower, progress made with this system in naval vessels. The battleship Dreadnought must always hold high place, especially as an example of the adaptability of the turbine to the problem of armour protection of the vital machinery parts of a warship installation. With the installations of reaction turbines in the battle cruisers Lion and Queen Mary and in the battleships Queen Elizabeth, Warspite and Malaya, and of impulse turbines in the battle cruiser Tiger, the battleships Barham and Valiant, and in the still more powerful battle cruisers Repulse and Renown, the application of the direct-connected turbine progressed in ships of His Majesty's Navy to a power level much in excess of the highest achieved with this system in merchant vessels.

In tracing the development of the direct turbine system, a natural analogy with the development of the reciprocating engine, in the endeavour for greater economy in fuel, is suggested as being of interest. The single high-pressure unit, exhausting to a single low-pressure unit, may be considered analogous to the two-cylinder compound reciprocating engine, while the single high-pressure turbine unit, exhausting to a pair of low-pressure turbines, may be termed a three-unit compound system. In the Carmania, in smaller-powered installations of cross-channel ships and in comparatively low-powered naval vessels, there were many examples of this three-unit compound system, but there appears no instance of it finding favour in highly-powered ships. Similarly, in the propulsive system adopted in the Imperator (Berengaria), the Aquitania (Fig. 5, on Plate VI), and the Vaterland (Leviathan), the arrangement of single high-pressure, single intermediate-pressure and two low-pressure turbines is similar in purpose to the four-cylinder triple-expansion engine. With installations such as those in the Lusitania and Mauretania, the endeavour for higher fuel economy was limited by the size of the turbine units, which condition dictated the further subdivision of the expansion range. The building in Germany of the Imperator and Vaterland, and of the Aquitania in Great Britain at about the same period—all of moderate power—clearly indicates endeavour for increased fuel economy and increase in revenue earning, rather than any effort to surpass the performance of earlier ships in speed. It has been stated by the owners that the Aquitania has proved highly successful, and, with minor turbine adjustments and with boilers converted to oil burning, she is now, after more than a quarter of a century, in constant operation, consistently maintaining a higher speed than ever before.

Mr. Stanley S. Cook, in his lecture, already referred to, dealt very fully with the first practical application of mechanical gearing to ship propulsion in the Vespasian; and, while it is stated that the gearing was introduced primarily to extend the utility of the steam turbine to the propulsion of low-powered ships, enabling the turbine to operate at the high revolutions and the propeller at the lower revolutions conducive to greater overall efficiency, there can be little doubt that Sir Charles Parsons visualised also the ultimate employment of mechanical reduction gearing in highly-powered ships. In this class of vessel, the reciprocating engine had entirely given place to the direct-connected turbine, but the lower propeller efficiency obtaining with the higher revolutions of the direct-connected propeller largely nullified the higher engine efficiency. In 15 years' time the power output had increased three-fold, yet the relative saving in fuel had been less than 10 per cent.

The machinery of the battle cruiser H.M.S. Hood, developing fully 150,000 shaft horse-power, may be cited as the first highly-powered geared installation. The power required for this ship was not a large advance over that of the battle cruisers Repulse and Renown, and it would have been entirely feasible to propel the Hood by direct-connected turbines. This is in contrast to the problem of the Lusitania and Mauretania, where the limitations of the reciprocating engine definitely dictated a change of system of propulsion. The adoption of gearing in the Hood was not dictated by necessity, which clearly indicates that, by 1915, experience with mechanical gearing had advanced sufficiently to justify geared transmission of power in this important vessel, the most highly-powered capital ship in any of the world's navies.

The direct-connected turbine was so designed that the thrust of the propeller would be wholly, or very largely, countered by the steam-pressure load upon the turbine rotor, and afforded long respite as regards the design of thrust block. With the adoption of double-helical gearing, however, the full thrust had to be taken upon the thrust block for direct transmission to the ship's structure. It is probably no exaggeration to state that, were it not for the single-collar thrust block, propulsion by geared turbines could not have been adopted in H.M.S. Hood. Hesitancy in accepting the single collar to take the full thrust affected progress in design in a very similar degree to the acceptance of the turbines as replacing the reciprocating engine, and of the geared turbine as replacing the direct-connected turbine. At an early date Sir Charles Parsons realised the necessity of departure from the multi-collar thrust block, and adopted the thrust block with single collar and pivoted thrust pads. In America, Kingsbury had developed a thrust block, centrally pivoted, of similar principle, but to Michell must be given credit for the inception of the single-collar tilting-pad thrust block so commonly used to-day.

The logical theory that greater overall fuel economy has resulted by operating the turbine at relatively high revolutions, and the propeller at relatively low revolutions, is to-day universally accepted, and its accomplishment by employing mechanical reduction gearing has gained favour in far greater degree than any other means. The large advance in overall efficiency cannot, however, be attributed solely to high turbine speed and lower propeller speed. With the adoption of turbines, the practice of driving all auxiliaries by steam piston engines became general, and proved so dependable that the adoption of other motive power for auxiliaries was long delayed. Departure from this established practice resulted from the action of owners' superintending engineers, who advocated electric motors for auxiliary drive much in advance of their willing acceptance by the builders of the propelling machinery, who feared that damage and even disaster might result through mishap to the electricity supply, more especially with such vital auxiliaries as steering gear, main circulating pumps, forced-lubrication pumps, etc. Electric-motor drive for auxiliaries effected a marked reduction in the overall fuel consumption, although to somewhat less degree in highly-powered ships.

The adoption of the water-tube boiler in merchant vessels made a further advance in fuel economy. Much earlier, and before the adoption of geared turbines, water-tube boilers had become universal in naval vessels, but the pressure had not greatly exceeded that obtaining with cylindrical fire-tube boilers. Superheating of the steam was also moderate, while air heating and feed-water heating were either very moderate or entirely absent. Oil-fuel firing with water-tube boilers had become common practice in naval ships; for example, H.M.S. Hood is fitted with water-tube boilers of 235 lb. (gauge) working pressure,

without superheaters or air heating, and with very limited feed heating.

With the adoption of gearing it was realised that the reduction in dimensions of the turbines, which may be seen in Fig. 7, on page 79, rendered possible the use of higher pressures and temperatures; and to demonstrate this the Parsons Marine Steam Turbine Company fitted machinery of high pressure and superheat, in conjunction with water-tube boilers, in the Clyde steamer King George V. The performance of this vessel led the Canadian Pacific Steamship Company to depart from their usual practice, through the initiative of their superintendent engineer, Mr. John Johnson, by the adoption of high-pressure water-tube boilers in ships of the Duchess class. Mr. Johnson then startled the shipbuilders by specifying drastic advances in the fast North-Atlantic ship Empress of Britain. For propulsion, there were nine water-tube boilers (eight Yarrow and one Johnson), of larger size than were then fitted in any merchant vessel, with a working pressure of 425 lb. (gauge), superheaters to raise the steam temperature to 725 deg. F., boiler feed water at 300 deg. F., and air heaters to reduce the temperature of the combustion gases to 275 deg. F. Two cylindrical fire-tube boilers supplied steam for the "hotel" services, and also effected first evaporation of the feed water for the water-tube boilers. Oil firing was employed with all boilers. High-, intermediate-, and low-pressure turbines, receiving steam at about 375 lb. pressure and exhausting at a vacuum of 29 in., transmitted power through a single-reduction gear to each of the four propellers, and were arranged as shown in Fig. 6, on Plate VI. The power transmitted to the two inner propellers was double that of the two outer propellers; thus, while, on the Atlantic service, all four units would be employed, operating the inner shaft units only would suffice for such reduced-power service as world cruising. The fuel consumption to be guaranteed showed the expectation of economy in advance of anything previously accomplished by steam-driven engines; and the fulfilment of all specified conditions at the trials and in service served to establish for steam-driven highly-powered ships a rate of expenditure in operation comparable with that of lower-powered ships propelled by oil engines.

The high-pressure and intermediate turbines were of unusually high length-over-diameter ratio, and "hogging" of these casings occurred during warming-up to such a degree that the necessary clearance of the blading tips and shrouding could be maintained only by most careful attention to the warming-up. It is suggested that such large ratio of length to diameter be avoided, even to the extent of adopting the more intricate four-turbine unit.

(To be continued.)

CATALOGUES.

Temperature Indicator.—A pamphlet sent to us by Messrs. Negretti and Zambra, 38, Holborn-viaduct, London, E.C.1, describes their multi-point temperature indicator.

Cut-Outs for Colliery Use.—We have received from Messrs. British Insulated Cables, Limited, Prescot, Lancashire, a folder illustrating their single-pole, double-pole and four-pole cut-outs, mounted in moulded non-conducting cases, for use in colliery electrical systems.

Machine Tools.—From Messrs. Dowding and Doll, Limited, 3, The Green, Wimbledon Common, London, S.W.19, we have received a folder illustrating the British and American machine tools (including lathes, millers, grinders, presses, etc.) for which they are selling agents.

Shelter Ventilation.—A folder describing the use of Vent-Axia extractors for ventilating air-raid shelters has been received from Messrs. Vent-Axia, Limited, 9, Victoria-street, London, S.W.1. These units, which are stated to be weatherproof, silent, lightproof, and suitable for continuous running, can be adapted also for intake purposes.

Valves.—In forwarding to us their handbook of valves, Messrs. Saunders Valve Company, Limited, Cwmbran, Newport, Monmouthshire, mention that the production of their new straightway valve has been retarded by the heavy demand for the diaphragm valves, which are the main subject of the brochure. It is expected that normal production of the straight-way type will be achieved shortly.

SOVIET TRADE REPRESENTATION IN THE UNITED KINGDOM.—With reference to Article 5 (2) of the Anglo-Soviet Temporary Commercial Agreement of February 16, 1934, the Ambassador of the U.S.S.R. has notified H.M. Government in the United Kingdom that the offices of the Soviet Trade Delegation have been removed from 51-53, Hatton-garden, London, E.C.1, to "Westfield," 32, West Hill, Highgate, London, N.6.

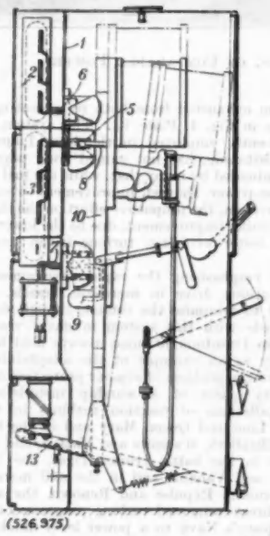
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

526,975. Duplicate 'Bus-Bar Switchgear. The British Thomson-Houston Company, Limited, of London, H. E. Cox and A. C. Gibson, of London. (2 *Figs.*) March 30, 1939.—The invention is an improved form of duplicate 'bus-bar switchgear in which isolation and 'bus bar selection is simplified. The fixed portion of the gear includes a vertical panel 1 carrying the duplicate sets of 'bus-bars 2, 3, and cable connections. Each of the sets of 'bus-bars has fixed plugging contacts 5, 6, respectively, and the cable connections have plugging contacts 7, which are engaged by sets of contacts 8 and 9 at the breaker. Side panels attached to the edges of the panel 1 form an enclosure for the fixed and movable portions of the gear. The movable portion of the gear consists of a supporting structure 10 in which the air-break circuit breaker is mounted. The supporting



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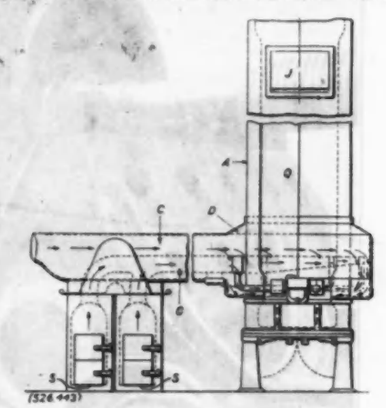
structure is pivoted at the foot on the ends of a pair of links 13, pivoted on the fixed part of the gear so that the structure 10 can be swung outwards to the dotted line position for isolation and 'bus bar selection. The plugging contacts 8, 9 are mounted on the supporting structure and connected to the two terminals of the breaker. The contact 9 is made double, so that one or other prong engages the plugging contact 7 according to the vertical position of the structure 10. A lever and link gear operate the structure 10 through the pivot shaft of the links 13. The breaker is operated manually by a handle, which is coupled to it by a flexible cable. After the supporting structure 10 has been swung outwards it can be raised or lowered to its other position, and when it is moved inwards, one prong of the contact 9 engages the contact 7 connected to the cable terminal, while the contact 8 engages the plugging contact associated with the other set of 'bus bars. (*Accepted September 30, 1940.*)

FURNACE APPARATUS.

526,443. Cupola Furnace. E. Longdon, of Manchester. (2 *Figs.*) March 16, 1939.—The invention is a cupola furnace which enables the carbon content of the iron to be kept low by reducing the fuel consumption and lessening the period of contact of the iron with the fuel layers. The furnace proper is of usual construction, having a steel shell A with a refractory lining, a central heating shaft Q, a wind belt D feeding the air-inlet ports, and a charging door J. Twin gas generators S are arranged at one side of the cupola A, in which hot gases, mainly carbon monoxide, are produced and passed to a hot-gas main G, the outlets into the main being controlled by dampers to permit of alternate working of the generators. The hot-gas main is surrounded by an air-blast main C with an insulating covering, the air being drawn in by a fan. The main G. is connected to a gas-distribution pipe surrounding the furnace in the wind belt D and provided with tuyeres through which the hot gases enter the combustion zone of the cupola. The air-



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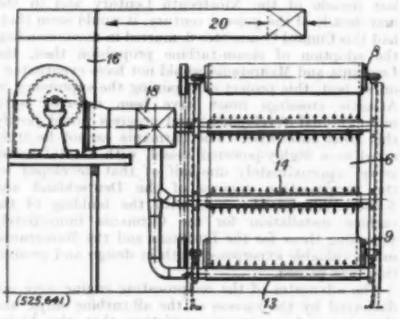
blast main C connects with the wind belt D and the air, pre-heated by its passage along the main, is forced into the furnace through air-inlet ports. By this construction the incompletely burned hot gases from the twin generators S are supplied separately to the combustion zone of the cupola, and, moreover, since the temperature of the hot gases falls while that of the air increases as they travel along their respective mains, the temperatures of the gases and of the air can be made substantially equal at entry into the combustion zone by correct choice of the lengths of main. Such a furnace reduces the quantity of fuel consumed and consequently the depth of the layers of fuel. It also allows for a delivery of between 25 per cent. and 60 per cent. of the heat units required for melting from the primary combustion fireboxes, the remainder of the heat units being provided by the fuel charged into the furnace and burned in the area where the primary hot gases, mainly carbon monoxide, and air enter the furnace. (*Accepted September 18, 1940.*)

MISCELLANEOUS.

525,641. Paper-Maturing Machine. Sturtevant Engineering Company, Limited, of London, and M. F. Stevens, of London. (5 *Figs.*) February 24, 1939.—The machine is of the kind in which the paper web travels in a zig-zag path up and down, and air of the required temperature and humidity is blown on to the paper. In the new machine, a very much greater amount of web is simultaneously exposed to the humid air than has been the case hitherto. The paper web 6 passes in a zig-zag path over upper and lower spar drums 8 and 9, to a take-up reel, being supported between two sets of endless tapes. Between and slightly below each pair of adjacent lower



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spar drums 9 is an air-distributor duct 13, which runs horizontally across the width of the paper web and is provided with jets through which humid air is discharged upwards. Between each pair of adjacent vertical runs of the web 6 are two further ducts 14 at different levels, each discharging humid air upwards and downwards on each side. Air of the required temperature and humidity is supplied to the ducts 13 and 14 from a humidifier and heater 16 through a main air trunk 18 to which the ducts 13 and 14 are connected. An exhaust duct 20 above the upper drums 8 collects the air rising from the paper, this duct being connected to the inlet of the humidifier and heater. (*Accepted September 2, 1940.*)